Climate-Smart Agriculture in Cocoa

A Training Manual for Field Officers

World Cocoa Foundation

Rainforest Alliance

With support from:

CGIAR RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

CCAFS

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GHANA COCOA BOARD

Climate-Smart Agriculture in Cocoa

A Training Manual for Field Officers

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Climate-Smart Agriculture in Cocoa

January 2018

Introduction

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Introduction

This training manual has been developed to raise awareness among cocoa farmers in Ghana on the effects of climate change on their cocoa production and to give them tools (in the form of recommendations) to mitigate these (negative) effects. The topics can be used by field/extension officers in addition to topics on good agricultural practices.

Climate Change Impact Zones

The recommendations to mitigate negative effects of climate change are provided according to 3 zones (see also additional information in topic 1):

- **Coping and opportunity zone** in which climatic conditions are predicted to stay or become relatively favorable for cocoa production with low changes to the actual suitability.
- **Adjustment zone** in which higher annual average temperature; weaker dry season (short, with comparatively higher rainfall in the driest quarter); and higher annual rainfall are expected.
- **Transformation zone** in which higher temperatures and reduced rainfall, prolonged dry season, and drought are expected.

Adaptation Levels of Farmers

In order to enable a continuous improvement pathway to achieving greater resilience against climate change, four levels of adaptation have been developed (see also additional information in topic 1):

1. Minimum
2. Bronze
3. Silver
4. Gold

The **minimum level** basically corresponds with the minimal requirements of practice implementation at the farm level to achieve a basic level of resilience against the various climate hazards and threats that define a specific impact zone.

The other levels built on these requirements in terms of effort and investment needed but also include aspects such as collective actions at the community, landscape or policy level (see topic 9 on enabling environment). **Gold** indicates the maximum actions farmers can take to safeguard and possibly improve their natural habitat. **Bronze and silver** build upon the minimum recommendations and are part of a continuous improvement path towards gold.

How does this training manual work?

The training manual consists of eight topics. Every topic contains the following sections:

1. **Key information:** A summary of the most important information the participants need to know by the end of the session. The fact sheets contain a summary of recommendations on how to deal with certain (negative) effects of climate change for that specific topic.
2. **Climate-smart agricultural practices:** In this table, you will find all recommendations per climate change impact zone (coping and opportunity, adjustment, and transformation zone) and per adaptation level (minimum, bronze, silver, and gold).
3. **Additional information:** This is background information for the trainer to better understand the topic. That means that this information does not have to be transferred to the participants. Further reading may be necessary if the trainer is not familiar with the topic.
4. **Guidelines for trainers:** The training model used in this manual (see the SDF model below) helps the trainer to structure the training sessions and to transfer the technical information in the correct way to the audience.

The SDF-Model

The SDF-model consists of three phases:

1. Set up
2. Delivery
3. Finish

Each phase consists of certain steps:

SET UP

- ☑ **Attention:** Get the attention of the audience, for example by asking a question, showing something, telling a story related to the topic, etc.
- ☑ **Title:** Give the title of the topic.
- ☑ **Objectives:** Explain what will be learned during this session.
- ☑ **Benefits:** Explain the advantages when applying the knowledge (what is in it for them?).
- ☑ **Direction:** Set the boundaries of your session by explaining what will be discussed and what not.

DELIVERY

- ☑ **Explanation:** Provide details on the topic by speaking.
- ☑ **Demonstration:** Visualize the topic, you can use pictures, visuals, real materials but also examples and role plays.
- ☑ **Exercise:** Let the audience do an exercise to learn through practice (doing).
- ☑ **Guidance:** Guide the audience throughout the topic to ensure you stay within the topic.

FINISH

- ☑ **Summary:** Summarize the key information. Do not re-explain the whole topic, just mention the key points.
- ☑ **Questions:** Allow the audience to ask any question or provide additional comments.
- ☑ **Evaluation:** Test the understanding of the audience by asking questions about the key information.
- ☑ **Next step:** Mention how the learning can be put into practice.

Learning and Application of Knowledge and Skills

Please keep in mind that training is not just about the transfer of knowledge and skills; training is about changing the behavior of people so they are willing to apply the knowledge and skills. For that they need to see the benefits of what they have learned (“what's in it for me?”), have the confidence to apply the knowledge and skills (“I can do it!”), and the commitment to do it (“I will do it”). Also take into account that you do not change people's behavior by telling them what to do differently; it is rather by guiding them through the process and asking questions to let them discover things themselves.

Contact

In case you have any comments, suggestions and/or questions, please contact Sander Muilerman: sander.muilerman@worldcocoa.org or Christian Mensah: cmensah@ra.org

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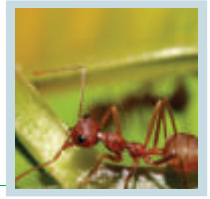

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Topic 1

Climate-Smart Agriculture

FACT SHEET

Climate Change

The climate is the **regular weather conditions** of an area. For example, the start and intensity of a rainy season, and average temperatures. We talk about **climate change** when those weather patterns **become different** in the medium to long term. For example, the rainy season might become shorter or less intense, and average temperatures could rise. Agriculture, including cocoa production, depends on the weather and many activities are planned according to the season that are defined by certain weather patterns and climatic conditions. If those patterns and conditions change it can have a profound **impact** on cocoa production.

Here are a few examples of **changes in the climate** and its possible **impact** on cocoa **production** listed in the table below:

Climate change	Possible impact on cocoa production
Drought: a prolonged period of abnormally low rainfall; a shortage of water resulting from this. 	• Plants wilting and drying up – high seedling mortality. • Smaller beans. • Increased attack by capsid and other insects. • Pesticide application might have different expected results. • Cherelle wilt. • Flower abortion. • Decrease in yield.
(Prolonged) intensive rainfall: prolonged rainy season or rainy hours, extreme weather events such as heavy thunderstorms 	• High seedling mortality. • Increased humidity, resulting in increased diseases such as black pod, stem canker, pink disease and other fungal diseases. • Possible invasion of new diseases. • Damage to flowers which can result in huge losses of potential fruits (flower abortion). • Increased fruit fall. • Roots exposed as topsoil is washed away and soil erosion leading to soil nutrient depletion. • Landslides which can uproot cocoa trees. • High water content, longer time for drying needed which will lead to a higher risk of mold contaminations of beans. • Decrease in yield.

Climate change	Possible impact on cocoa production
Temperature changes: higher annual mean, higher maximum temperature of warmest month, higher mean temperature of warmest quarter 	• Decrease in yield. • Stomatal closure leading to reduced photosynthesis/photochemistry. • Reduced flower and fruit production. • Wilting of leaves. • Smaller bean size. • Changes in pest and disease dynamic i.e. preferred conditions that increase incidence in pests and diseases; pests that need higher temperature to survive start to show up on farms (habitat change). • High seedling mortality.
Prolonged dry season: at least 3 consecutive months with less than 100mm rainfall 	• Smaller beans. • Increased attack by capsid (helopeltis) and other insects. • Flower abortion. • Plants wilting and drying up. • Decrease in yield. • Increased rates of bush fires which can destroy (part of) your farm.

Climate-Smart Agriculture in Cocoa

Climate-Smart Agriculture (CSA) aims to mitigate the negative impact of climate change on cocoa production and to adapt your agricultural practices, if necessary. CSA is not one action; it is rather an approach consisting of several possible actions. CSA is also not a "one-fits-all" approach that is the same for every cocoa farmer in Ghana; it depends on the specific impact of climate change (the identified climate threat) in a certain area and the capacity of the farmer to respond to this and apply suitable CSA practices.

Some areas will be more affected than others. This means that in areas where impacts are predicted to be minimal, you should focus on applying sustainable agricultural practices that helps to build more resilient cocoa systems overall. In addition, you should protect any remaining forests and avoid further degradation of those. In areas where climate impacts are more prominent, you will need to adapt your cocoa farming practices to ensure productivity and sustainability over the long term. Unfortunately, there will also be areas where cocoa production will become extremely difficult and more drastic action is needed. The different adaption strategies are being described in the following sessions in more detail.

Adaptation levels

As cocoa farmer, you will need to change (or adapt) your current agricultural practices depending on the location of your farm but also on what you want and are able to do. Not everyone can or is willing to invest the same amount of time, effort and financial resources in his/her farm. Therefore, you will find for every technical session throughout this manual, recommendations for specific climate impact zones (described below), but also for different adaptation levels. It is up to you to decide which are the most important actions based on your circumstances to implement and whether you want to focus on the minimum recommended actions, some of them, or all of them.

Topic 1: Climate-Smart Agriculture

ADDITIONAL INFORMATION

Climate-Smart Agriculture Practice Recommendations

For every technical topic, a variety of recommendations will be provided, depending on 2 indicators:

1. Climate change impact zone
2. Adaptation level of the farmer

1. Climate Change Impact Zones

Although the climate in the whole of Ghana is predicted to change, the consequences for cocoa are not the same in every location. A map has been developed for Ghana which showcases the impact of climate change on cocoa. These are grouped into zones which are defined according to a gradient of impact:

- **Coping and opportunity** (indicated in the map in light and dark green)

  Description of impacts: climatic conditions are predicted to stay or become relatively favorable with low changes to the actual suitability

  These two zones will become or remain suitable for cocoa production, even under a business-as-usual scenario. The focus is less on any specific hazard as a main strategy but more broadly on setting up and promoting best management practices that enhance system resilience and sustainability overall. These practices would also feature in any agriculture standard or agriculture manual to improve productivity and sustainability of cocoa production. Protecting remaining forests is an important component of this.

- **Adjustment zone** (indicated in the map in yellow and orange)

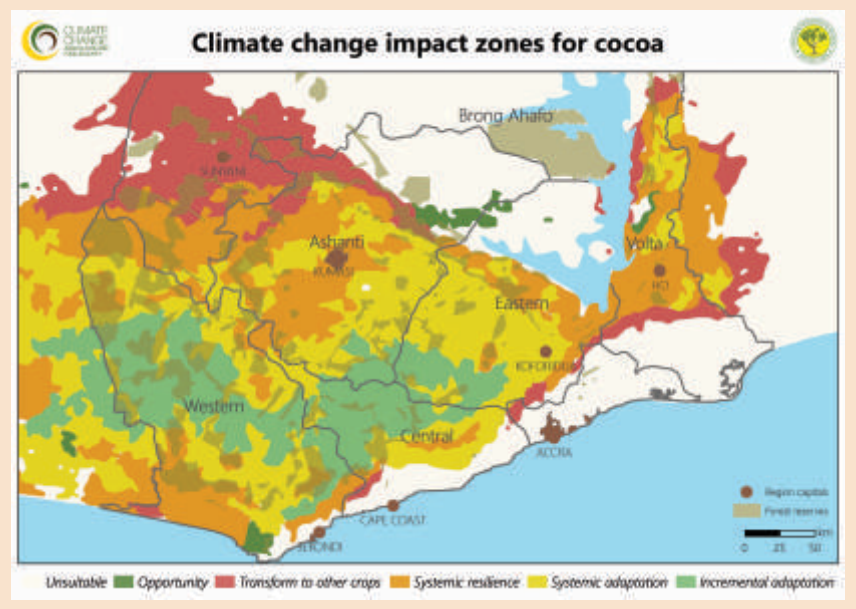
  Description of impacts: Higher annual average temperature; weaker dry season (short, with comparatively higher rainfall in the driest quarter); higher annual rainfall.

  These two zones show either systemic adaptation (yellow) or systemic resilience (orange). **Systemic adaptation** indicates a high certainty of change (specific hazards/threats that have been identified) that requires systemic adaptation of the cocoa farming system to ensure productivity at current levels. **Systemic resilience** points to a high uncertainty of remaining suitability (unclear climate hazards) which calls for adaptation that maximally raises the overall resilience to climate change of the farming system. The focus under systemic adaptation would be on strategies that address higher annual average temperatures, weak dry season (short, with comparatively higher precipitation in the driest quarter) and overall higher annual precipitation. Within systemic resilience, the focus is on implementing and promoting best management practices that similar to the coping zone emphasizes practices that build more generally stronger agricultural systems and sustainability overall. Focus here would be on so called no-regret solutions such as shade enhancement or diversification with suitable tree species that are known to have a multitude of benefits and protect against a series of possible threats.

Transformation zone (indicated in the map in red)

Description of impacts: Higher temperatures and reduced rainfall, prolonged dry season, drought

Areas in this transformation category were found to become unsuitable for cocoa production in the future. Production in these zones will likely become unviable or transitioning to alternative crops appears to be more efficient than extensive adaptation efforts. In the case of Ghana and cocoa, this could for example be through diversifying cocoa shade systems with more suited and drought tolerant tree species that would allow for cocoa to be phased out completely over the long term. In the short term, drip irrigation could support immediate adaptation of the current production system whilst preparing for a transition into a suitable alternative. Another solution might be for areas of cocoa that are in need of replanting to be replaced by other cash crops such as shea and cashew or food crops.



2. Adaptation Levels of Farmers

In order to enable a continuous improvement pathway to achieving greater resilience against climate change four levels of adaptation have been developed:

1. Minimum
2. Bronze
3. Silver
4. Gold

The **minimum level** basically corresponds with the minimal requirements of practice implementation at the farm level to achieve a basic level of resilience against the various climate hazards and threats that define a specific impact zone.

The other levels built on these requirements in terms of effort and investment needed but also include aspects such as collective actions at the community, landscape or policy level (see topic 9 on enabling environment). **Gold** indicates the maximum actions farmers can take to safeguard and possibly improve their natural habitat. **Bronze and silver** build upon the minimum recommendations and are part of a continuous improvement path towards gold.

It is up to the farmer to decide what he/she wants and can do. It is not necessary that a farmer applies the bronze or gold recommendations for every activity in the field; the action he/she chooses to implement can **vary** per agricultural practice.

Topic 1: Climate-Smart Agriculture

GUIDELINES FOR TRAINERS

Materials needed:

- ☑ None

Time needed:

1 to 1.5 hours (depending on the length of your discussions under point 7)

Preparations:

- ☑ Carefully read the fact sheet, additional information and guidelines.
- ☑ Print the 4 drawings at the end of this topic depicting different aspects of climate changes (drought, intensive rainfall, temperature change, and prolonged dry season). You can laminate them so you can use them several times.
- ☑ Print the 4 drawing at the end of this topic depicting the impact of the different changes in climate.

Set up

Attention:

Ask people if they are smart (your question will probably raise some confused looks and then some laughs). Then ask what it means to be smart. It means you are clever and make the right decisions. Also in agriculture, you will need to make the right decisions in a given context and that is exactly what we are going to discuss today: how to make the right decisions with regards to agriculture in a changing climate.

Title:

Mention the title of the session: Climate-Smart Agriculture.

Objectives:

To explain what climate-smart agriculture is and what the consequences are of changing climate on our cocoa.

Benefits:

A changing climate can have negative effects on our cocoa. If you know what the impact can be, you can better prepare yourself to deal with the consequences but most importantly be more resilient and suffer less impact i.e. reduced yields as a result.

Direction:

During this session, we will not yet discuss what you can do to mitigate the negative consequences. That will be discussed in other sessions.

Delivery

Explanation, Demonstration, Exercise, and Guidance:

1. Say that there is a lot of talk about **climate change**. Ask if anyone can explain what **climate/climate change** is. Let several people answer before you give the correct answer: the climate is the **regular weather conditions** of an area. For example, the start and intensity of a rainy season, and average temperatures. Continue by saying that we talk about **climate change** when those weather patterns **become different** in the long term. For example, the rainy season will become shorter or less intense, and average temperatures rise.

2. Ask participants **how long** they have been growing cocoa. Let several people answer. Ask if they have **observed any changes** in the weather patterns over the last few decades. Let several people answer. When no more suggestions come, summarize all changes that were mentioned.

3. Say that agriculture, including cocoa production, **hugely depends on the weather** and many activities are planned according to the season that coincides with certain weather patterns. If those patterns change it will have an **impact** on cocoa production. We are going to discuss what the consequences are for four changes in climate:

    a. **Drought:** a prolonged period of abnormally low rainfall; a shortage of water resulting from this.
    b. **(Prolonged) intensive rainfall:** prolonged rainy season or rainy hours, extreme weather events such as heavy thunderstorms.
    c. **Temperature changes:** higher annual mean, higher maximum temperature of warmest month, higher mean temperature of warmest quarter.
    d. **Prolonged dry season:** at least 3 consecutive months with less than 100mm rainfall.

4. Ask all participants to stand up and **form a line** according to their height. Split participants into **4 groups** according to their place in the line (so for example when you have 14 people, the first 3 people will form group 1, the next 3 people will form group 2, the next 4 people will form group 3, and the last 4 people will form group 4). Give each group a drawing with a climate change on it: “drought”, “(prolonged) intensive rainfall”, “temperature” or “prolonged dry season”. Each group has to discuss what the **possible impact** (consequences) is on their cocoa farm for their climate change.

    Note for the trainer: The method to split people into 4 groups is to mix people and to make them move around a bit to energize them before they sit down again to discuss.

    Note for the trainer: There is no need to let the groups write their answers on flip-sheets, because it will only distract them from the discussion. Just let them discuss.

5. Let the groups discuss. **Move around to guide** the groups is necessary.

6. **Optional additional exercise:** When the groups have finished their discussions, tell them that before they are going to present what they have discussed, they need to demonstrate in a role play how the specific aspect of climate change they have discussed, will affect their lives.

7. **Discuss the results**. In case you added the exercise on the role play, let the first group start their play. Ask other groups to observe carefully. At the end, ask the other groups what they observed. Then let every group summarize what they have discussed. Ask if other groups have questions and/or would like to add something. Try to get a lively discussion and ask people for their personal experience (try to find linkages with their role play and refer to it). Make sure all points as mentioned in the fact sheet are mentioned.

   Note for the trainer: The discussion should be focused on the **consequences of climate change, not** on what farmers can do about it. In case the discussion turns in that direction, remind participants that we will discuss this later.

   Note for the trainer: It is not necessary to write answers on flip-sheets. Focus on having a good discussion in which all aspects are discussed.

8. At the end of every discussion on a certain aspect of climate change, **show the drawings** depicting the impact of climate change for every aspect that was discussed.

Finish

Summary:

Give a summary by repeating what climate change is and the impacts on cocoa.

Questions:

Ask if anyone has a question or comment.

Evaluation:

Ask the following questions:

- What could the consequences of drought be on our cocoa farm?
- What could the consequences of a change in temperature be on our cocoa farm?

Next step:

We have discussed how climate change can impact our cocoa farm. When you go back to your farm, see if you can recognize any of the changes that we have discussed and start thinking about strategies and practices that you could implement to make your farm stronger and more resilient.

Topic 2: Establishment Phase

FACT SHEET

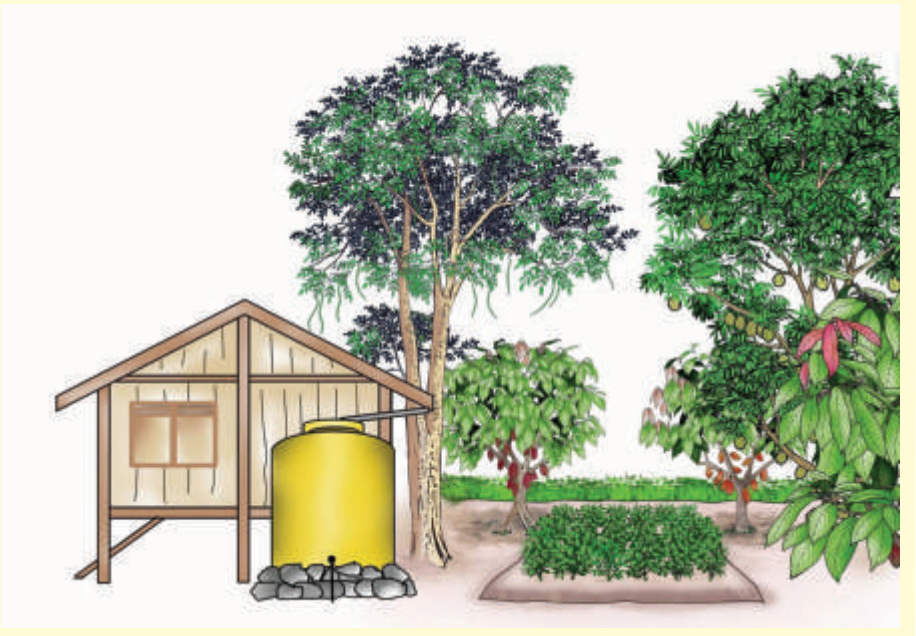
The **establishment phase** includes the following activities needed to establish a cocoa farm:

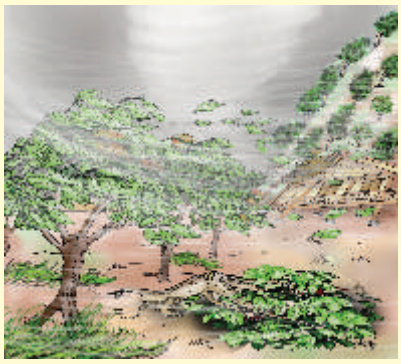
- Land selection and preparations
- Land management
- Nursery management
- Seed stock
- Temporary and permanent shade
- Planting and replanting

How does climate change impact the establishment phase of a cocoa farm?

Changes in climatic conditions and weather patterns such as higher temperatures, drought or heavy rainfall can negatively affect for example nutrient availability and moisture levels that are crucial in the development of seedling growth. The visible impact will be as follows for each zone:

Zone	Predicted Impact
Coping and opportunity	Climatic conditions are predicted to stay relatively favorable to grow cocoa. However, you need to check the conditions on the farm, i.e. soil fertility, water availability, erosion, etc. to ensure it is suitable to plant cocoa.



Zone	Predicted Impact	
Adjustment zone (systemic adaptation and resilience)	Higher temperatures can cause reduced availability of water and drier soils among others. Long dry seasons can lead to reduced yields. Higher and heavier rainfall can cause erosion, less fertilize soil, risk of flooding, etc. In addition, there can be unpredictable changes that can have different effects on the farm.	
Transformation zone	Prolonged dry season, reduction in rainfall, drought. This means that the soil will be very dry and there will be reduced water availability among others.	

Deforestation

When you would like to establish a cocoa farm or expand your existing farm, you should not (and in fact you are not allowed to by law) clear a wide area of trees (called **deforestation**) and use it for cocoa production. You should carefully look at the vegetation and trees on the land and make an effort to keep desired species. **Deforestation** can have a **negative impact** on the environment. The most dramatic impact is a **loss of habitat** for millions of species, including beneficial insects, because their homes will be destroyed when all trees and bushes are cleared. Deforestation also **drives climate change** and can increase the negative impact of changes in the weather pattern.

1. Land Selection and Preparations

Already during land preparations, you can do a lot to make your cocoa more resilient, for example by helping to retain **more moisture and nutrients** in the soil. In addition to your general good agricultural practices, such as correct spacing and compost preparation, the following recommendations that apply across the different impact zones should be considered to combat higher temperatures and less rain that can lead to drought conditions and nutrient depletion.

Intercropping

Intercropping means placing **another crop** between the cocoa seedlings. You can plant the following crops:

- To provide **temporary and permanent shade**.
  - Plant plantain, cocoyam, banana, and other annuals, *Terminalia ivorensis* (emere), *T. superba* (ofram), *Spathodea camnulata* (kuokuonisuo) etc. **to protect cocoa seedlings** from the direct impact of sun rays. For example, cassava should be considered as an alternative for the coping zone.
  - As much as possible, crops should be planted **a year before** you plant your cocoa seedlings so your seedlings will be protected from the sun the moment they are planted. Where this is not practical, your temporary shade such as plantain should be planted very close to the new cocoa seedlings to offer as much protection as possible.
- To provide **moisture**.
  - Plant seedlings next to temporary shade of **plantain** so the roots of the seedlings can access the soil moisture reserves that are usually retained by plantain pseudo-stems in case of drought. In addition, the plantain leaves will protect the seedlings from direct sun radiation.
  - Crops that provide shade will also moderate soil and air temperature so providing a more favourable microclimate.
- To provide **nutrients**, prevent erosion, improve soil structure, and improve ground cover.
  - Plant **leguminous species** as groundnuts, beans and cowpea as **cover crops**, especially in zones with higher temperatures and heavier rains that will wash away nutrients.
  - Plant *Plumeria Tephrosia spp* (part of the pea family), *Flemingia macrophylla* (woody leguminous shrub) and *Mucuna* as cover crops **prior** to introduction of cocoa for improved fallow/uncultivated land to increase resilience when planting cocoa.

Plumeria ssp

Flemingia macrophylla

Mucuna (velvet beans)

  - Plant trees, such as Gliricidia spp, to provide nutrients in the form of organic matter from the trees, and to prevent erosion and improve the soil structure because of the roots (for recommended trees, see topic 5 on Tree management).

Gliricidia spp

Fertilization

The first step is to check the level of nutrients in the soil on your farm to see find out what nutrients might be missing (see also topic 6 on Soil management). In case the soil is depleted of nutrients, you will need to add extra nutrients for the seedlings to grow. You can add:

- **Manure in planting holes:** this practice is recommended for zones that are only slightly affected by climate change impacts, i.e. the coping and opportunity zones.
- **Compost tea to transplanted seedlings:** this practice is necessary in zones were climate change impacts are expected to have a significant impact, i.e. the adjustment zone.
- **Fertilizer to transplanted seedlings:** this practice goes one step further than compost tea and is recommended for farmers that are able to support seedling development through this method if necessary.

Compost Tea

Materials needed: buckets, fresh compost, shovel, water, and a straining cloth.

Steps to prepare compost tea	Visual
Step 1: Fill a bucket for 1/3 full of quality finished compost.	
Step 2: Add water up to the top of the bucket (good well water will do).	
Step 3: Let the mixture steep for 3-4 days. Stir it now and then.	
Step 4: Strain the mixture through cheesecloth or other porous fabric (burlap, old shirt) into another bucket. Add the remaining solids to your compost bin.	

Step 5: Dilute the remaining liquid with water so it is the color of weak tea (use a 10:1 ratio of water to tea).

Step 6: Use tea immediately for optimal absorption into the soil around plants. Simply pour the tea from the bucket around the root system at the base of the plant.

Recommendations for Land Preparations

- *All zones*
  - As minimum level, manual clearing without burning, spacing of 3x3m for hybrid or 2.5x2.5m for grafting, compost preparations.
- *Coping and risk zone*
  - As minimum level, use of manure in planting holes, temporal shade with plantain.
  - Progress by adding land selection and preparations using Integrated Pest Management (IPM) criteria, intercrop with temporal shade and cover crops, and other leguminous species.
- *Adjustment zone*
  - As minimum level, use of manure in planting holes, establish/maintain temporary shade.
  - Progress by establishing temporary shade at least 1 year ahead.
  - Intercrop with leguminous species for all levels.
- *Transformation zone*
  - As minimum level, temporary shade. Progress by establishing temporary shade at least 1 year ahead.
  - As minimum level, application of compost tea to transplanted seedling. Progress by adding fertilizer.
  - For all levels, Intercrop with leguminous species, plant seedling next to plantain shade crop, cover crops for improved fallow before planting.

2. Land Management

Irrespective of the effect of climate change impacts, you should weed your land 4 times a year after planting. After weeding, leave the debris to serve as mulch on the farm floor. Where necessary, provide water for newly planted seedlings in case of long dry periods.

3. Nursery Management

Increased heat and drier conditions can make it challenging for seedlings to grow into full productive cocoa trees. As such it is important to **retain moisture and add nutrients** when needed to make the seedlings more resilient and grow to between 3-6 months before transplanting in the field. For this, you can for example use fortified substrate including **compost/treated manure**) for the transplanting of seedlings to give them a head start.

4. Seed Stock

An appropriate way to ensure that seedlings grow into healthy and productive cocoa trees, is by using **quality planting materials**, irrespective of the impact zone you live in. What type of planting materials you purchase, depends on your willingness to invest in your farm and their availability. At the minimum you should try to use **hybrid seeds/seedlings** from a certified seed production place, e.g. the seed production division of COCOBOD. Even better would be to source seeds/seedlings that are more pest/disease and drought tolerant, or grafted seedlings that are pest resistant.

5. Temporary and permanent shade

Both temporary and permanent shade are recommended for cocoa seedlings and mature trees right from the beginning of establishing your cocoa farm (see also topic 5 on tree management). The more severe the climate impacts on your farm, the more important it becomes to consider **enhancing shade** through planting **additional trees** to reduce the negative impact. It is however important to remember that shade trees need to be **selected according to their traits** to avoid competition for nutrients and water, and in addition need to be **managed carefully** to provide the needed benefits and microclimate. It is important to note that it is critical to have **adequate shade** for cocoa **always**.

6. Replanting

When replanting an old or diseased cocoa farm it is important to use **good planting materials** that are resilient in order to avoid any obvious challenges in the area. With more challenging climate conditions, it can become **more difficult to grow new cocoa and shade trees**. One technique that can be used is **coppicing** of the old cocoa stem. Another technique that can increase the resilience of plants is that of grafting. **Grafting** is a technique used to join parts from two or more plants so that they appear to grow as a single plant. In grafting, the **upper part** (scion) of one plant **grows on the root system** (rootstock) of another plant. Grafting is recommended in all zones for farmers who have the opportunity and capacity to do so.

Despite being labor intensive, grafting has several **advantages**:

- It promotes the use of a root system **better adapted to soil or climate** than that produced naturally by an un-grafted plant.
- It **shortens the time taken to first production** of flowers or fruits by the scion, in some cases by many years.
- It produces **dwarf plants** with the same qualities as the original trees and makes both the **height and shape more convenient** for harvesting of fruits, pruning and application of pesticides.
- It ensures that trees **retain their desirable leaf, floral, or fruit characters**, without the risk of these being lost through sexual reproduction.

Because of the risk of the Cocoa Swollen Shoot Virus and you need specific skills, it is **not advised to try to graft on your own**. In case you are interested, you should **contact your community extension agent** to discuss if grafting is an option.

Other Recommendations

Land Management

- *All zones:* Weed 4 times a year and use debris as mulch and green manure.

Nursery Management

- Use of compost/treated manure or other fortified substrate is recommended for advanced levels in the adjustment zone and all levels in the transformation zone. Grow seedlings to 3-6 months before transplanting to the field.

Seed stock

- *All zones:* Use of hybrid seedlings from COCOBOD as a minimum for all zones. It is recommended to use more disease/pest and drought tolerant varieties for the next level and pest resistant (if in existence) grafted seedlings for higher levels if available.

Shade Trees

- *All zones*: Temporary and permanent shade should be established in all zones. For the two higher levels, this should be established a year before transplanting.
- Coping and risk zone: Ranges from 15, 18, 20 to 25 trees that will provide 30-40% shade cover per hectare.
- *Adjustment zone*: Ranges from 20, 25, 35 to 45 trees that will provide 40-50% shade cover per hectare.
- *Transformation zone*: Ranges from 25, 30 to 50 (for both advanced levels) trees 50-70% shade cover per hectare.

Replanting

- *All zones*: As minimum, replanting with high yielding hybrid seedlings is recommended. For the advanced levels in all zones, grafting of mother trees is recommended in combination with seedling replanting. For silver, an increased plant density is recommended in addition, while gold level farmers should add an intensive pruning regime.

More on the topic of the establishment of a cocoa farm can be found in the Manual for Cocoa Extension in Ghana, chapter 3.1 nursery practices, 3.2 on Preplanting operations, and 3.3 cocoa field planting practices.

Topic 2: Establishment Phase

Climate-Smart Agricultural Practices

MINIMUM	BRONZE	SILVER	GOLD
LAND PREPARATIONS			
All zones			
Manual clearing without burning	Land selection and preparations using IPM criteria		
Spacing of 3x3m for hybrid or 2.5x2.5m for grafting			
Compost preparations			
Coping and risk zone			
Use of manure or recommended inorganic fertilizer in planting holes			
Temporary and permanent shade with plantain, cassava, fruit and timber trees etc.	Intercrop with temporary and permanent shade and cover crops and other leguminous species (Gliricidia spp, groundnuts, beans and cow pea)		
Adjustment zone			
Use of manure in planting holes			
Establish/maintain temporary and permanent shade (e.g. plantains, cocoyam, cassava, banana, and other annuals, fruit and timber trees)	Establish temporary and permanent shade (plantain, cocoyam, banana, and other annuals, fruit and timber trees) at least 1 year ahead		
Intercrop with leguminous species e.g. Gliricidia spp, groundnuts, beans and cow pea			
Transformation zone			
Temporary and permanent shade (e.g. plantains, cocoyam, cassava, banana, and other annuals, fruit and timber trees)	Temporary and permanent shade (e.g. plantains, cocoyam, cassava, banana, and other annuals, fruit and timber trees) at least 1 year ahead		

	Cover crops (maize, plantain, cocoyam and other leguminous species e.g. Gliricidia spp)
Application of compost tea to transplanted seedlings	Add fertilizer to transplanted seedling
Intercrop with leguminous species e.g. Gliricidia spp, groundnuts, beans and cow pea	
Plant seedling next to plantain shade crop for seedling roots to access the soil moisture reserves usually retained by plantain pseudo stems	
Adopt Plumeria Tephrosia spp, Flemingia macrophylla and Mucuna pruriens for improved fallow with other timber and fruit trees prior to introduction of cocoa, improved soil nutrient content and to enhance soil moisture	

LAND MANAGEMENT

All zones

Weeding 4 times a year

NURSERY MANAGEMENT

Adjustment zone

	Use fortified substrate including compost/treated manure for nursing and transplanting of seedlings for robustness. Grow seedlings to 6 months before transplanting

Transformation zone

Use fortified substrate including compost/treated manure for nursing and transplanting of seedlings for robustness. Grow seedlings to 6 months before transplanting.

SEED STOCK

All zones

Use hybrid seedlings from COCOBOD	Use recommended planting materials including disease/pest tolerant varieties of cocoa	Use pest or drought resistant grafted seedlings

SHADE

All zones

Temporary and permanent shade of plantain, cocoyam and Gliricidia spp, fruit trees and timber trees	1 year established temporary and permanent shade of plantain, cocoyam and Gliricidia spp, etc.

Coping and risk zone			
Shade canopy of 30-40% with 15-18 trees per hectare	Shade canopy of 30-40% with18 trees per hectare	Shade canopy of 30-40% with 20 trees per hectare	Shade canopy of 30-40% with 25 trees per hectare
Adjustment zone			
Shade canopy of 20 trees per hectare	Shade canopy of 40-50% with 25 trees per hectare	Shade canopy of 40-50% with 35 trees per hectare	Shade canopy of 40-50% with 45 trees per hectare
Transformation zone			
Shade canopy of 25 trees per hectare	Shade canopy of 50-70% with 30 trees per hectare	Shade canopy of 50-70% with 50 trees per hectare	Shade canopy of 50-70% with 70 trees per hectare
REPLANTING			
All zones			
Replanting with high yielding hybrid seedlings	Combined seedling replanting with grafting of mother trees	Combined seedling replanting with grafting of mother trees with increasing plant density	Grafting mother trees and increasing tree density with high-yielding seedlings and intensive pruning regime

Topic 2: Establishment Phase

GUIDELINES FOR TRAINERS

Materials needed:

- ☑ 5 sheets/cards and a marker for your preparations
- ☑ Masking tape
- ☑ For transformation zone: materials to prepare compost tea (bucket, compost, cloth, stick to stir, water)
- ☑ Compost to show to the participants
- ☑ One cocoa seedling
- ☑ A drawing or picture of a grafted seedling (or a real one)
- ☑ *Plumeria Tephrosia spp, Flemingia macrophylla* and *Mucuna*. In case you cannot find it, print the pictures at the end of this topic.
- ☑ The drawings from topic 1 that depict consequences of climate changes

Time needed:

60-90 minutes (depending on the level of participants)

Preparations:

- ☑ Carefully read the fact sheet, additional information and guidelines.
- ☑ The best is to facilitate this session on a farm that has recently planted cocoa seedlings and several shade and cover crops. Make sure you know what type of crops are used as shade and cover crops. In case it not possible to do the session on a farm, prepare a drawing or show a picture of a young cocoa farm with shade and cover crops.
- ☑ For transformation zone: read carefully all the steps on how to prepare compost tea (to be demonstrated under point 8). In case you have never prepared this before, you should try it before the training session to ensure you do not make any mistakes during the program.
- ☑ For adjustment and transformation zone: under point 9 you need to demonstrate how to transplant using compost. Make sure you know how to do this (see topic 3.3 on holding and transplanting of nursed seedlings of the Manual for Cocoa Extension in Ghana for general information on how to transplant seedlings).
- ☑ Prepare five cards or sheets with all steps of the establishment phase (one step per sheet/card):
    - Land preparations
    - Nursery management
    - Seed stock
    - Shade
    - Replanting
- ☑ This topic can be used in addition to topic 3.2 on replanting, land preparation, and shade establishment of the Manual for Cocoa Extension in Ghana.

Note for the trainer:

This topic is about establishing (or expanding) a cocoa farm so does not necessarily have to be discussed with farmers with an existing or mature cocoa farm. Some parts might be useful when replanting.

Note for the trainer:

You need to look carefully at the recommendations blocks or the table with the Climate-Smart Agricultural Practices to see what you need to recommend to your audience or how to answer certain questions depending on the zone you are in. In some cases, it is indicated when information is only for a certain zone. Not all details of the recommendations are added in the guidelines. Depending on your audience you can add extra information.

Note for the trainer:

Land management is not discussed because the recommendation is the same for all farmers, irrespective zone or level. If you want to, you can mention the general recommendation.

Set up

Attention:

Ask participants who of them has established or replanted a cocoa farm before. Let people raise their hands. Say that they know that a lot needs to be done. When the climate changes, you need to take some precautions when establishing or replanting a cocoa farm.

Title:

Tell the title of the session: Establishment phase.

Objectives:

To discuss what we need to take into account when establishing or replanting a cocoa farm in a changing climate.

Benefits:

When you establish your farm in the correct way, you can ensure that your seedlings will grow to its full potential by mitigating the negative impact of climate change. The result will be healthy cocoa trees that produce a lot of cocoa.

Direction:

Some issues we will discuss, are also valid for grown cocoa trees, However, during this session, we will focus on the establishment phase.

Delivery

Explanation, Demonstration, Exercise, and Guidance:

1. Ask if someone can **repeat** some of the **changes** in climate we discussed during the previous session (session 1 on CSA).
2. Show the 5 sheets/cards with all **steps of the establishment phase** and read them out loud before pasting them on the wall/board. Ask the following questions (the answers depend largely on the zone where you are in, so prepare yourself well to know the correct answer):
    a. *What will the consequence of climate change impacts for the land on which we want to establish a cocoa farm?* See page 1 of the fact sheet for the impact in different zones.
    b. *What will the consequence of climate change impacts for the seedlings we are going to plant?* See page 1 of the fact sheet for the impact in different zones.
    c. Show the drawings from topic 1 that depict the impact of climate change.
3. Say that fortunately, we can **adapt our agricultural practices** to mitigate all these negative effects. However, before we start discussing land preparations it is important to know that when you would like to establish a cocoa farm or expand your existing farm, you should **not** (and in fact you are **not allowed to by law**) clear a wide area of trees (called **deforestation**) and use it for cocoa production. Ask: *What could be the negative consequences for the environment when we clear a wide area of trees for cocoa production?* Let several people answer. **Deforestation** can have a **negative impact** on the environment. The most dramatic impact is a **loss of habitat** for millions of species, including beneficial insects, because their homes will be destroyed when all trees and bushes are cleared. Deforestation also **drives climate change** and can increase the negative impact of changes in the weather pattern.
4. We will now look at **land preparations**. Already during this step, you can do a lot **to retain moisture and nutrients in the soil**. Ask the following questions:
    a. *What is planted between the seedlings?* There are other crops.
    b. *What type of crops do we see?* Let people have a close look and let them answer. Correct when necessary.
    c. *Why are these crops planted between the seedlings?* Let several people answer. Then summarize the answers: to provide shade, moisture, and nutrients, to prevent erosion, to improve soil structure, and to suppress weeds.
    d. *What type of crops are good to plant for temporary and permanent shade?* Let people shortly discuss the question with their neighbour for 1-2 minutes. Then collect answers from every group. Ensure plantain, cocoyam, cassava, and banana are mentioned.
    e. *For what type of climate change do we need to take extra care through temporary and permanent shade?* When the climate becomes hotter and drier because the direct sun will damage the seedlings. In drier climates, the crops should be planted a year before you plant your seedlings, so your seedlings will be protected from the sun the moment they are planted.
    f. (Only for transformation zone). Point to some plantain. *Ask: What benefits we will get when we plant seedlings next to plantain?* The roots of the seedlings can access the soil moisture reserves that are usually retained by plantain pseudo stems in case of drought. The plantain leaves will protect the seedlings from direct sun radiation.
    g. (Only for transformation zone). *For what type climate change would you recommend to plant seedlings next to plantain?* For hotter and drier climates.

h. *What crops are good to provide extra nutrients to the soil?* Leguminous species as groundnuts, beans and cow pea.

l. (Only for transformation zone). Add that you can also plant *Plumeria Tephrosia spp, Flemingia macrophylla and Mucuna* as **cover crops prior to introduction of cocoa** for improved fallow/uncultivated land to increase resilience when planting cocoa. Show the pictures of Plumeria Tephrosia spp, Flemingia macrophylla and Mucuna (or point at them when they are planted at the farm).

5. The more severe the climate impacts on your farm, the more important it becomes **to consider enhancing shade** through planting additional trees to reduce the negative impact. It is however important to remember that shade trees need to be **selected according to their traits to avoid competition** for nutrients and water, and in addition need to be managed carefully to provide the needed benefits and microclimate. We will discuss shade trees in topic 5.

6. Show the cocoa seedling. Ask the following questions:

   a. *Where can I buy these seedlings?* Let several people answer. Say that it is best to buy **hybrid seedlings from COCOBOD**.

   b. *If I want to avoid that pests and diseases will attack my cocoa, what type of seedlings can I buy*? Seedlings that are pest/disease tolerant.

   c. Are they cheaper or more expensive than normal seedlings? They are more expensive.

   d. *And if I want to reduce the negative impact of drought?* I can use seedlings that are drought tolerant.

   e. *If I am willing to invest in my farm, why is it a good idea to invest in pest/disease or drought tolerant seedlings or grafted seedling that can be even pest resistant?* I will get a higher yield because less will be lost to pests and diseases, and it will be less affected by drought.

7. In case the soil is depleted from nutrients, you will need to add extra nutrients for the seedlings to grow. Ask:

   a. *What can we add in planting holes to give extra nutrients to the seedlings that is not too costly?* We can add manure.

   b. (Only for transformation zone). *When the climate become drier and hotter, manure will not be enough. What else can we add?* We can add fertilizer.

8. (Only for transformation zone). Say that in case you do not have or do not want to invest too much in your farm, you can also use **compost tea**. Ask if any of the participants has experience with preparing compost tea. In case some people have, you can ask them to **demonstrate** how to prepare it (see fact sheet for all steps) or to assist you when you prepare it. In case no one has any experience, you can do the demonstration yourself.

9. (Only for adjust and transformation zone). Say that when the climate becomes harder for seedlings to grow into full productive cocoa trees, you need to **retain moisture and add nutrients** to make the seedlings more resilient. Ask: *What can we add to the seedlings when we transplant them to give them a head start?* You can use fortified substrate including compost/treated manure). Show them the compost and **demonstrate how to transplant using compost**.

10. (Only for farmers who are replanting). Say that when **replanting**, a harsher environment because of climate change, can make it more difficult for the new trees to grow. Therefore, you need to optimize growing conditions, and even give the new trees a head start using grafting techniques. Ask: *Can someone explain what grafting is?* **Grafting** is a technique used to join parts from two or more plants so that they appear to grow as a single plant. In grafting, the upper part (scion) of one plant grows on the root system (rootstock) of another plant. Grafting is recommended in all zones for farmers who are willing and capable to invest in their farms.

11. Ask if someone can make a **drawing** of how grafting works. In case no one is willing (or knows), **show** your own drawing or picture. Ask:

    a. *What are the advantages of grafting?* Let several people answer (see fact sheet for answers).

    b. *Should every farmer use grafting?* No, only if you are able and willing to invest in your farm.

12. Add that because of the risk of the Cocoa Swollen Shoot Virus and you need specific skills it is not advised to try to graft on your own. In case you are interested, you should **contact your community extension agent** to discuss if grafting is an option.

Finish

Attention:

Summarize what crops to use for cover and shade crops, what can be planted for the transformation zone, recommended seedlings and replanting recommendations (if applicable).

Questions:

Ask if anyone has a question or comment.

Evaluation:

Ask the following questions:

- What crops are good to use as cover crops?
- What crops are good to use for temporary shade?
- (Transformation zone only). What are other recommendations we have heard?
- What is grafting?
- What are advantages of grafting?

Next step:

When establishing your cocoa farm, carefully look at the recommendations to ensure that you establish a cocoa farm with productive cocoa trees.

Topic 3

Pest and Disease Management

FACT SHEET

Pests and Diseases Control

Disease prevalence in cocoa systems is influenced by **host plant availability for food and shelter, temperature and humidity conditions, rainfall and the health of the cocoa plant**. Climate change will influence these factors and will have implications for cocoa pests and diseases dynamics. Adverse climatic conditions which lead to stress (reduced vigor) in cocoa, will influence **susceptibility** of the crop to disease and pest attacks. An explosion in the population of pests that are hitherto considered minor pests due to their insignificant economic impact may become major pests as a result of climatic change. It is even possible that you will detect pests and diseases you never had noticed on your farm before.

The **impact of climate change** on pests and diseases includes:

- Beneficial insects will be reduced because their natural environment will change.
- When the climate becomes drier and hotter, there will be more competition for nutrients and water resources.
- More and heavier rainfall often lead to more humid and wet conditions which can be a breeding ground for pests and diseases.

Source: http://croplife.org/wp-content/uploads/pdf_files/Climate-Change-Brochure.pdf

Examples of beneficial insects

Weaver ants (*Occuphylla* species) against capsid

More specific impacts on certain pests and diseases are as follows:

	Intensified rainfall	Temperature changes	Drought	Prolonged dry season
INSECTS				
1. Capsids > *Sahlbergella singularis* > *Distanttiella theobroma* 	Capsids are often washed to the ground by intense rains but at the same time, rain can increase the occurrence of capsids.	Capsids breed best in temperatures between 24-26 degrees Celsius. Current research suggests that temperatures lower than 24 degrees Celsius or higher than 26 degrees Celsius will not favor the breeding activities of capsids.	Capsids do well in sunlight so can occur more during drought.	Prolonged drought conditions are unfavorable to capsids.
2. Stem borers *Eulophonotus myrmeleon* 	The population of stemborers might increase during intensified rainfall.	Stemborers are less likely to survive during cold periods.	Damage is more severe since less moisture is present in the stem.	Prolonged dry season favors the damage done to the cocoa plant.
3. Mealy bugs > *Planococcoides njalensis* > *Planococcus citri*  	The mealybug population might reduce in numbers with prolonged intensive rainfalls. Intensified rainfall will likely increase the ant population. There will likely be less mealybugs when there are different ant species on the farm.	High temperatures favor population growth with more eggs being laid. Ants will probably be less active.	Mealybugs survive in drought. Ants will probably be less active.	The mealybug population declines as it rises in the drought resistant alternate host plants. Ants will probably be less active.

	Intensified rainfall	Temperature changes	Drought	Prolonged dry season
INSECTS				
4. Shield (stink) bugs *Bathyloelia thallasina* 	Prolonged rainfall can wash the shield bugs off pods and shoots so they will probably do less damage.	They occur especially during periods with higher temperatures.	Drought does not favor their activities much.	A prolonged dry season might reduce their numbers since there are less shoots and pods to feed on.
5. Pod borer *Chiaraconmastriti grapha*  	The population of pod borers will likely increase during intensified rainfall.	High temperatures might lower the activities of pod borers, while their activities can increase when temperatures are lower.	Drought can reduce activities of pod borers.	A prolonged dry season can reduce activities of pod borers.
6. Aphids *Toxoptera aurantii* 	Rainfall favors their occurrences with the availability of fresh leaves/flushes.	Higher temperatures favor their breed / multiplication with the availability of fresh leaves.	Their presence during drought might be reduced since no fresh leaves or flushes are available to feed on.	Their presence during prolonged drought is significantly less since no fresh leaves or flushes are available to feed on.
7. Leaf 'defoliators' caterpillars *Anomis leona (recently mistaken for fall army worms)* 	The pest activities are intensified with the presence of fresh flushes or new succulent leaves.	Higher temperatures favor their breeding activities.	Their activities can be less, since no fresh flushes are available to feed on.	Their numbers can reduce with no fresh new leaves to feed on.

	Intensified rainfall	Temperature changes	Drought	Prolonged dry season
INSECTS				
8. Termites *Isopteran termitidae*  	The termites might move deeper into the ground to avoid the very wet and often soggy surfaces. Especially young and old cocoa trees can be severely damaged by termites.	Higher temperatures allow termites to move above the ground in search of moisture and can attach the roots and stem. Especially young and old cocoa trees can be severely damaged by termites.	Termites will likely occur more frequently because the soil is less wet and they will come to the roots and stem of the cocoa plant in search of moisture. Especially young and old cocoa trees can be severely damaged by termites.	Termites will likely occur more frequently because the soil is less wet and they will come to the roots and stem of the cocoa plant in search of moisture. Especially young and old cocoa trees can be severely damaged by termites.
FUNGI, BACTERIA, VIRUSES				
9. Black pod *Phytothora SSP* 	> The fungi that causes black pod (Phytophthora species) are water loving, and therefore, conditions that tend to create a humid and damp environment favors the development and spread of the disease. > One way the disease spreads is by rain drops splashing fungal spores onto healthy pods or drips of water from an infected pod falling directly onto healthy pods.	Higher temperatures are less favorable for the development of the fungi. Hence, they will probably occur less.	During drought, spores developed by the fungi are dormant in the soil and are unable to develop or spread.	With prolonged drought conditions, the fungus has the ability to survive in flower cushions, mummified (dry) pods, pod husks or in the soil. Once it starts raining again, they can resume activity.
10. Cocoa Swollen Shoot Virus 	The vector (mealybug) will probably reduce in numbers with prolonged intensive rainfalls so there will be less CSSV..	The vector (mealybug) can lay more eggs in warmer temperatures and CSSV will likely occur more.	The CSSVD vector (mealybug) can survive in drought conditions.	Vector population will probably decline so there might be less CSSV.

	Intensified rainfall	Temperature changes	Drought	Prolonged dry season
FUNGI, BACTERIA, VIRUSES				
11. Stem canker > *Phytophthora palmivora* > *Phytophthora megakarya* 	With intensive rainfall, the spores of the fungi that were dormant, now find favorable conditions for development and spread.	High temperatures are less favorable for the development and spread of the fungi.	During drought periods, the fungi spores stay dormant in the flower cushions.	A prolonged dry season can favor the fungi to lay dormant, and therefore might be less damaging to plants.
12. Thread blight > *Marasmius byssicola* > *Marasmius scandens* 	The development of the fungi can occur more in wet and damp conditions. Intensified rainfall will probably increase the occurrence of thread blight.	High temperatures dry up mycelia threads on branches/leaves and there will probably be less occurrence of thread blight.	There will probably be less occurrence of thread blight due to unfavorable conditions.	There will probably be less occurrence of thread blight due to unfavorable conditions.
13. Pink disease *Phanerochaete salmonicolor* 	Intensive rain/splashes can spread the spores of the fungus.	Might favor spore development of the fungi so the disease might spread quicker.	Total damage to branches will probably increase due to favorable conditions.	The fungi can develop spores on branches and infection can commence from the start of the dry season.
WEEDS				
14. Mistetoe > *Tapinanthus bangwensis* > *Phragman theraincana* 	Seeds from mistletoes sticks on branches/crevices and might germinate faster.	High temperatures can reduce fast germination rates and spread.	Some germinated seedlings may wither off or dry off.	Some germinated seedlings may wither off or dry off.

	Intensified rainfall	Temperature changes	Drought	Prolonged dry season
RODENTS				
15. Rodents 	The population of rodents will probably increase with intensified rainfall.	Rodents will probably withstand any change of temperature.	Rodents will probably remain active.	Rodents will probably remain active.
STORAGE PESTS				
16. Storage pests *Warehouse moth (Ephestia cautella), Rice moth (Corcyra cephalonica), Red flour beetle (Tribolium castaneum), Cigarette beetle (Lasioderma serricorne), Coffee bean beetle (Araecerus fasciculatus), Corn sap beetle (Carpophilus dimidiatus) and Rusty grain beetle (Cryptolestes ferrugineus).*	These storage pests thrive under high humid conditions with prolonged intensive rainfall and high temperatures. Especially moths will probably increase in population.	Higher temperatures can lead to an increase of storage pests because they will be looking for food and water.	Drought can lead to an increase of insect pests because they will be looking for food and water.	A prolonged dry season can lead to an increase of insect pests because they will be looking for food and water.

Courtesy: Dr A. R. Cudjoe, Entomologist
Dr. R. Adu-Acheampong, Entomologist CRIG
Mr Kofi Larbi, Librarian CRIG

Warehouse moth (*Ephestia cautella*)

Rice moth (*Corcyra cephalonica*)

Red flour beetle (*Tribolium castaneum*)

Cigarette beetle (*Lasioderma serricorne*)

Coffee bean beetle (*Araecerus fasciculatus*)

Corn sap beetle *(Carpophilus dimidiatus)*

Rusty grain beetle (*Cryptolestes ferrugineus*)

This means that your current methods to control pests and diseases on your farm might **no longer be sufficient**.

Calendar application versus Integrated Pest Management (IPM)

Black pod and capsids are the most common pests/diseases on cocoa farms in West Africa. To avoid that they attack the farm, most farmers apply insecticides and fungicides **preventive**, also called **calendar application** (because you apply them during a certain period of the year). Integrated Pest Management (IPM) makes use of **different practices** to prevent and control pests and diseases. In IPM, the **situation on the farm** is taken into consideration when selecting preventive and control methods. It can happen that for the same pest, a different method or a combination of methods will be applied on different farms or over time because of different circumstances.

Calendar application

The following applications are recommended to prevent and control black pod and capsids:

- Black pod: May to December. One application of fungicides per month.
- Capsids: August to December. One application of insecticides per month, omitting November.

Source: Manual for cocoa extension in Ghana

Reduction of pesticides use

You can reduce the use of pesticides by:

- **Prevention of** pests and diseases so there is less need to use pesticides to control pests and diseases.
- Use of **other control methods**.
- **Application of the recommended dosage** when applying pesticides. The recommended dosage is written on the pesticide label. Over-application of pesticides will not control the pest or disease better; it will only cost you extra money, harm beneficial insects, and increase the risk of contaminating people and the environment.
- The **identification and monitoring** of pest population and threshold for chemical control enables farmers to apply the right chemical, in the right proportion/dosage and at the right time to effectively control the pest.
- **Targeted application** of pesticide enables farmers to avoid applying pesticides where it is not necessary.
- **Correct spraying practices** through proper calibration and performance of sprayers.
- When spraying insecticides, watch out for **dripping** from the pods or leaves. This usually means you are wasting insecticides.

See also Manual for Cocoa Extension in Ghana: Chapter 3.10 on Integrated Crop, Pests and Disease Management, 3.10.1 on Management of Cocoa Diseases, 3.10.2 on Mistletoe and Other Epiphytes, 3.10.3 Management of Cocoa Pests.

Recommendations for pest & disease control improvements

- As minimum level, apply pesticides for black pod and capsids based on calendar spraying.
- Progress from calendar spraying to pesticide application based on IPM principles for all zones.
- Reduce the use of pesticides in all zones up to 30% for coping and risk zone.

Weed Control

Controlling weeds on your farm is seen as a good agricultural practice because some **weeds** such as over-grown noxious weeds, e.g., *Imperata cylindrical* and *Chromolaena odorata* **compete for nutrients, sunlight, and water with your cocoa trees**. Especially cocoa seedlings and young cocoa trees are vulnerable to weed competition, and their growth will be reduced when weeds use a big portion of the nutrients, sunlight, and water. Taller cocoa trees will cast shade which will reduce the weeds.

Examples of **noxious weeds** on the cocoa farm that are harmful:

Mimosa pudica

Cyperus pilosus

You can do the following to **manage weeds** on your cocoa farm:

- **Weed regularly.** When you weed regularly (at least three times a year), you can remove all weeds with cutlass and there will be no need to use herbicides. Repeated use of herbicide will not only cost you money, it will also degrade soil, expose the soil surface to the air, and makes it more vulnerable to climate change. The space around your cocoa trees should be weed free.
- **Plant cover crops.** Cover crops planted between cocoa trees will avoid that weeds can grow at those places. It also helps to build and improve soil fertility by protecting the soil from sunlight and erosion. Good cover crops are legumes, such as groundnuts, beans and cowpea.
- **Mulching** means covering the soil with organic residues such as palm fronds or cut weeds placed between the rows (only in case the weeds do not contain any pests or diseases, otherwise they should be removed from the farm). Be careful of not putting uprooted noxious weeds between the rows, as they revive and start to spread on the farm again. Uprooted noxious weeds need to be taken out of the farm. Mulching will protect the soil from sunlight and erosion. When the organic residues rot, they will give the soil organic matter.

Soft weeds are very helpful in keeping the soil covered, retaining the soil moisture, preventing soil erosion, and some of them are leguminous and can even fix nitrogen. It is mainly the **noxious weeds** that are pests for our cocoa trees.

See also Manual for Cocoa Extension in Ghana: Chapter 3.7 on Weed Management.

Recommendations for weed control improvements

- As minimum level, control weeds at least 3 times a year.
- Progress for all zones from weed control at least 3 times a year to weed control based on farm conditions.
- For all zones, add cover crops to regular weeding.
- For all zones, add mulching to cover crops and regular weeding.

Always record your preventive and control methods so you know which methods work well on your farm and to be able to rotate methods, if necessary.

Topic 3: Pest and Disease Management

Climate-Smart Agricultural Practices

MINIMUM	BRONZE	SILVER	GOLD
PEST AND DISEASE CONTROL			
All zones			
Pesticide application for black pod and capsids based on calendar spraying	Pesticide application based on IPM principles		
Coping and risk zone			
		20% reduction of use of pesticides	30% reduction of use of pesticides
Adjustment zone			
		Rotation of IPM principles	
		Reduction of use of pesticides	20% reduction of use of pesticides
Transformation zone			
		Rotation of IPM principles	
		Reduction of use of pesticides	
WEED CONTROL			
All zones			
Weed control at least 3 times a year	Weed control at least 3 times a year, but based on farm conditions	Regular weeding and cover crop	Regular weeding, cover crop and mulching

Topic 3: Pest and Disease Management

ADDITIONAL INFORMATION

Further reading

On climate change and pests and diseases:
http://croplife.org/wp-content/uploads/pdf_files/Climate-Change-Brochure.pdf

On pest and disease control in cocoa:
https://www.slideshare.net/chandankumarka/pest-disease-of-cocoa
http://www.dropdata.org/cocoa/icm_bkp.htm
https://www.slideshare.net/DENNIS90/diseases-and-pests-of-pre-harvest-cocoa

On pesticide application in cocoa:
http://www.dropdata.org/cocoa/Cocoa_Pesticides_Manual_Ed3.pdf

On Integrated Pest Management (IPM):
https://croplife.org/wp-content/uploads/pdf_files/Integrated-pest-management.pdf

On integrated Pest and Crop Management (ICPM):
S. David 2011. Good agricultural practices for sustainable cocoa production: a guide for farmer training. Manual 2: Integrated crop and pest management for mature cocoa farms. Sustainable Tree Crops Program, International Institute of Tropical Agriculture, Accra, Ghana. July 2011 version

A list of approved pesticides can be found in Appendix 2 and 3 of the Manual for Cocoa Extension in Ghana of COCOBOD.

Topic 3: Pest and Disease Management

GUIDELINES FOR TRAINERS

Materials needed:

- ☑ In case the group is literate, you can use flip-sheets and markers to write the meaning of the letters IPM, and list IPM preventive and control methods.
- ☑ The drawings used in topic 1 for drought, prolonged intensive rainfall, temperature changes, and prolonged dry season.
- ☑ 1 copy of each of the drawings/pictures of the pests and diseases at the end of this topic.
- ☑ Masking tape to paste all drawings on the wall.

Time needed:

90 minutes

Preparations:

- ☑ Carefully read the fact sheet, additional information, climate-smart agricultural practices, and guidelines.
- ☑ Check what type of group you have and select the steps in the Delivery Phase which you need to discuss with your group.

Note for the trainer: In the table with pests and diseases, you will see a total of 17 pests and diseases. It is not advised to discuss all of them, but rather make a selection of 4-5 major pests from different categories (insect, fungi, etc.) to increase the understanding of how climate change can affect a certain category of pests/diseases.

Note for the trainer: As you can see in the table with the Climate-Smart Agricultural Practices, there is not so much difference in recommendations between the different zones. Therefore, this topic is more focused on the different levels of farmers. You can also decide to discuss the whole topic so farmers can choose which recommendations they want to follow. Not all details per level and zone are provided in the guidelines. You can add them, depending on your participants.

Set up

Attention:

Ask participants what type of pests and diseases are common in their cocoa farms. Let several people answer. Say that pest and disease control is one of the aspects of our next topic.

Title:

Tell the title of the session: *Pest and disease management*.

Objectives:

To discuss what impact climate change has on certain types of pests and what we can do limit the negative consequences. We will discuss pest and disease control, the difference between calendar application and Integrated Pest Management (IPM), and weed control.

Benefits:

Pests and diseases can reduce your yields drastically and even destroy your cocoa farm. In a changing climate, you will notice that your normal methods to control pests and diseases might no longer work. At the end of this session, you will know what to do to prevent and control pests and diseases in a changing climate.

Direction:

Although we will mention IPM, we will not discuss how to practice IPM in cocoa because that is done in other technical training programs.

Delivery

Explanation, Demonstration, Exercise, and Guidance:

1. Say that they have mentioned several pests and diseases that can harm our cocoa. Disease prevalence in cocoa systems is influenced by **host plant availability for food and shelter, temperature and humidity conditions, rainfall and the health of the cocoa plant**. A **changing climate** will **have implications for** cocoa pests and diseases dynamics, meaning that some pests will increase, while others will be reduced. It is even possible that you will detect pests and diseases you never had noticed on your farm before.

2. **Show the drawings** that depict drought, prolonged intensive rainfall, temperature changes, and prolonged dry season. Repeat what they depict and paste them on the wall/board. **Show the drawing of aphids**. Ask: *Do you have a lot of aphids on their cocoa farm?* Probably not. Say that aphids are considered as a minor pest in cocoa. Refer to the drawings depicting the 4 different climate changes. Ask: *How will aphids be influenced by drought?* Will there be more or less aphids? Collect answers from several people before providing the correct answer (see the table in the fact sheet). Continue by asking how aphids will be influenced by prolonged intensive rainfall, temperature changes, and prolonged dry season.

3. Discuss **one more example** of a pest (for example stemborers) with the whole group.

4. Split participants into small groups (depending on how many pests and diseases you would like to discuss). Give each group 1 drawing of a different pest/disease that you did not discuss yet. Each group needs to discuss how their pest/disease will be **influenced** by any of the four climate changes. Give the groups enough time to work. **Walk around** to assist where necessary.

5. Discuss the **results**. Let the groups one by one present their results in the following way:
   a. One of them should hold the **drawing/picture** high so everyone can clearly see it.
   b. They should mention the **pest/disease** they have discussed.
   c. You point to the sun and ask what **effect drought** will have on this pest/disease. Let the group answer. Then ask if **other groups agree**.
   d. **Continue** with the intensive rainfall and follow the same steps. Do the same for temperature changes and prolonged dry season.
   e. Continue with the next group till all groups have presented their results.
   f. Ensure all information in the **fact sheet** is mentioned.

6. Continue by asking the following questions:
   a. *Can anyone mention a few **beneficial insects** (or natural enemies) on our cocoa farm?* Let several people answer. Make sure weaver ants (*Occuphylla* species) against capsid are mentioned.
   b. *In case the climate changes, what can be the **impact** on beneficial insects, and certain pests and diseases?* They might be reduced which means some pests and diseases will no longer be controlled by their natural enemies. New pests might also emerge which are currently not associated to the crop.

7. We have seen that climate change will affect pests and diseases, and beneficial insects. This means that your normal methods to control pests and diseases on your farm might **no longer be effective and efficient**. To ensure that you are well prepared for any type of climate change, simply applying pesticides to prevent pest and diseases will no longer be sufficient. Instead we need to apply **Integrated Pest Management** (IPM). IPM makes use of **different methods** to prevent and control pests and diseases. This means that you do not automatically apply pesticides but that you try to prevent pests and diseases, monitor the situation on your farm, and look at several methods and factors before deciding how to control pest and diseases.

8. Say that it is also recommended to **reduce the use of pesticides**, such as insecticides and fungicides. Ask: *How can we reduce the use of pesticides?* Let several people answer. You can reduce the use of pesticides by:
   - **Prevention** of pests and diseases so there is less need to use pesticides to control pests and diseases.
   - Use of **other control methods** as described above.
   - **Application of the recommended dosage** when applying pesticides. The recommended dosage is written on the pesticide label. Over-application of pesticides will not control the pest or disease better; it will only cost you extra money, harm beneficial insects, and increase the risk of contaminating people and the environment.

- The **correct identification and monitoring** of pest population and threshold for chemical control enables farmers to apply the right chemical, in the right proportion/dosage and at the right time to effectively control the pest.
- **Targeted application** of pesticide enables farmers to avoid applying pesticides where it is not necessary.
- **Improved spraying practices** through proper calibration and performance of sprayers.
- When spraying, watch out for **dripping** from the pods or leaves. This usually means one is wasting pesticides.

9. Say that a specific type of pest is **weed**. Ask the following questions:
   a. *Why are weeds considered a pest for our cocoa?* Weeds **compete** for nutrients, sunlight, and water with our cocoa trees.
   b. *Are all weeds a pest?* No. **Soft weeds are very helpful** in keeping the soil covered, retaining the soil moisture, preventing soil erosion, and some of them are leguminous and can even fix nitrogen. It is mainly the **noxious weeds** that are pests for our cocoa trees.
   c. *Can somebody mention an example of a noxious weed?* Imperata cylindrical and Chromolaena odorata.
   d. *Do noxious weeds mainly affect seedlings and young cocoa trees, or taller cocoa trees?* Especially cocoa seedlings and young cocoa trees are **vulnerable** to weed competition.
   e. *What it the reason for this?* Cocoa seedlings and young cocoa trees need a lot of nutrients, water and light to grow. In case they get less nutrients, water and light it will immediately affect their growth negatively. In addition, taller cocoa trees will cast shade which will reduce the weeds.

9. Say that therefore it is good practice to **control the weeds on your cocoa farm**. You should weed at **least 3 times a year**. In case you really want to control the weeds well, you should weed even more, depending on the situation on your farm. When you weed regularly, you can remove all weeds with cutlass and there will be no need to use herbicides. The space around your cocoa trees should be **weed free**.

Finish

Summary:

Repeat how climate change can impact specific pests and diseases. Repeat why they should control weeds.

Questions:

Ask if anyone has a question or comment.

Evaluation:

Ask the following questions:

- *How can climate change impact capsids?*
- *And black pod?*
- *What can we do to be prepared for all the changes?*

Next step:

Keep in mind that pests and diseases can reduce your yields drastically and even destroy your cocoa farm. To improve your pesticide application and weed control, start with XX (mention the practice for the group to move to a higher level).

Crop Management

FACT SHEET

Crop management includes all agricultural practices used to improve the health, development, and yield of your cocoa, including:

1. Pest, disease and weed control (this is discussed in topic 3)
2. Pruning
3. Fertilizer application (see also topic 6 on Soil management)
4. Harvesting
5. Fermentation
6. Drying
7. Storage

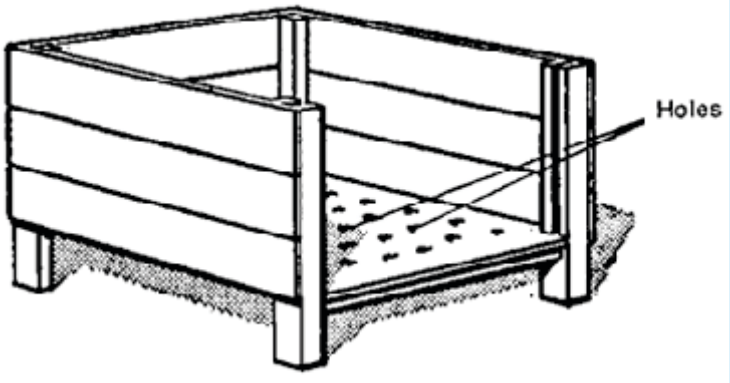
How does climate change impact crop management on a cocoa farm?

The visible impact will be as follows for each zone:

	Intensified rainfall	Temperature changes	Drought	Prolonged dry season
Pruning 	Branches can grow quicker. Pruning should be done to ensure stronger trees that recover faster. Be aware that also chupons can grow quicker so you will have to remove them more often.	Thick canopies can trap heat in the cocoa farm so pruning should be done regularly when temperatures get higher.	Primary branches and trunks can be more exposed to the direct impact of sunlight. The intensity and frequency of pruning should be moderated to avoid exposing primary branches and trunks to direct sunlight.	With less rain, trees can take a longer time to recover from pruning. Pruning should be done but the intensity and frequency of pruning should be moderated to avoid exposing primary branches and trunks to direct sunlight.

	Intensified rainfall	Temperature changes	Drought	Prolonged dry season
Fertilizer application 	There is the risk of fertilizer being washed away by heavy rains. You should only apply fertilizers when the rain is not too heavy or wait until after the rainfall. Foliar fertilizer should be applied one hour before the rain.	Fertilizer uptake by roots is supported by sufficient water availability in the soil. With higher temperatures, there might be less water in the soil and the uptake of fertilizers by the roots can be less easy. You should only apply fertilizer when rain is expected (apply after the rain to avoid run off) or you should water the plants after application of fertilizers.	Fertilizer uptake by roots is supported by sufficient water availability in the soil which might not be the case in drought conditions. You should only apply fertilizer when rain is expected (apply after the rain to avoid run off) or you should water the plants after application of fertilizers. In a dryer climate, it is better to apply foliar fertilizers instead of granules.	Fertilizer uptake by roots is supported by sufficient water availability in the soil which will be unlikely during a prolonged dry season. You should only apply fertilizer when rain is expected (apply after the rain to avoid run off) or you should water the plants after application of fertilizers. In a dryer climate, it is better to apply foliar fertilizers instead of granules.
Harvesting 	Heavy rain can cause an increase in infected pods by black pod and rotten beans, and therefore a reduction in marketable beans. It is important to harvest regularly (at last every 2-3 weeks) to avoid that infected pods will spread diseases to other pods. In addition, regular harvest will also avoid that the pod will lose weight.	Higher temperatures can reduce pod and bean size and can lead to small bean sizes due to less water availability. It is important to harvest if pods are matured although still small. They will not grow larger and will only get infected. Very low temperatures can increase the number of diseased/rotten matured pods and lead to more rotten beans. You should harvest in time with 2-3 weeks interval to avoid that infected pods will affect others.	Drought can cause a delay of pod maturation and will lead to reduced yields. You should harvest with 2-3 weeks interval but careful check if pods are matured enough to be harvested.	A prolonged dry season can cause a delay of pod maturation and will lead to small bean size. You should harvest with 2-3 weeks interval but careful check if pods are matured enough to be harvested.

	Intensified rainfall	Temperature changes	Drought	Prolonged dry season
Fermentation 	Intensified rainfall can slowdown the fermentation processes and can enhance contamination by mycotoxines (e.g. aflatoxins). Fermentation in wooden boxes or similar devices can prevent reducing or damaging the flavor attributes of the beans. The placenta needs to be removed before fermentation.	Temperature changes can reduce flavor quality or enhanced infection of mycotoxins. Fermentation in wooden boxes or similar devices can prevent reducing or damaging the flavor attributes of the beans. The placenta needs to be removed before fermentation.	Drought can have a negative effect on fermentation and can reduce flavor quality. Flavor can become more acidic. You should consider having a more appropriate fermentation process for instance in wooden boxes or “sweatboxes”. Be careful to know very well the type of beans (*Trinitario* or *Forestero/Amelonado*). The placenta needs to be removed before fermentation.	A prolonged dry season can create a high concentration of sugar in beans which makes them less suitable for fermentation. In addition, there can be negative effects on flavor formation, flavor type and intensity (e.g. high fructose and less amino acids in beans leading to poor flavor volatiles). Fermentation in wooden boxes or similar devices can prevent reducing or damaging the flavor attributes of the beans. The placenta needs to be removed before fermentation.



	Intensified rainfall	Temperature changes	Drought	Prolonged dry season
Drying 	If your beans are not properly dried, the risk of mold contamination is higher. This can reduce the quality of the beans which in turn can lead to a loss in earnings as inferior quality won't achieve the same price as higher quality beans or might even be refused by the buyer completely. You can look at alternative ways to dry your cocoa, for example using solar dryers (see below).	Drying will be quicker when temperatures are higher but slower when temperatures are lower. You can look at alternative ways to dry your cocoa, for example using solar dryers (see below).	Drying will be quicker. You need to be careful that the beans will not burn and lose quality. You might want to consider a light shade net to protect the beans from harsh sunlight.	Drying will be quicker. You need to be careful that the beans will not burn and lose quality. You might want to consider a light shade net to protect the beans from harsh sunlight.
Storage 	It is more challenging to store dry beans in a humid climate. More investment is needed for appropriate storage facilities and equipment (e.g. vegetable treated jute bags; ventilated rooms, etc.).	High temperatures can lead to an increase of storage pests, while low temperatures might lead to mycotoxins. More investment is needed for appropriate storage facilities and equipment (e.g. vegetable treated jute bags; ventilated rooms, etc.).	Drought can cause proliferation of insect pests, e.g. Ephestia cautella (warehouse moth) and Tribolium castaneum (red flour beetle). More investment is needed for appropriate storage facilities and equipment (e.g. vegetable treated jute bags; ventilated rooms, etc.).	A prolonged dry season can increase insect pests and reduce the shelve life of cocoa beans. More investment is needed in appropriate storage facilities and training should be sought in the management of stored products.

Solar dryers

With irregular weather patterns, such as less predictive rain, it will become **more difficult to dry your cocoa** in the proper way. **Solar dryers** are devices that use **solar** energy to dry substances, especially food, and are easy to construct.

A simple solar dryer is made out of wood and clear plastic. Drying should take place slowly. If the beans are dried too quickly some of the chemical reactions started in the fermentation process are not allowed to complete their work and the beans are acidic with a bitter flavor. However, if the drying is too slow, molds and off-flavors can develop. Various research studies indicate that bean temperatures during drying should not exceed 65 degrees Celsius (source: ICCO). On the internet are several examples showcasing dryers for cocoa.

Recommendations

Pruning

- *All zones:*
  - Formation pruning as minimum and desired for advanced levels
  - Structural pruning once a year
  - Sanitary pruning: 3 times a year as minimum, regular for bronze level and throughout the year for silver and gold
- *Transformation zone:*
  - Formation pruning as minimum, desired for bronze, and intensive for silver and gold

Fertilizer application

- *All zones:*
  - 3 bag inorganic fertilizer per acre (fallow period every 5th year) as minimum
  - Adding organic fertilizer for advanced level (8 bags per acre)
  - Adding inorganic fertilizer but dependent on soil or leaf analysis for silver and gold level

Harvesting

- *All zones:* at 2-3 week intervals

Drying

- *All zones:* Solar driers for advanced levels.

Post-harvest

- *All zones:*
  - 6-7 day fermentation, twice turning
  - Placenta inclusive but without for gold level

Storage

- *All zones:* Dry and aerated storage for all levels, and secured for silver and gold level

Topic 4: Crop Management

Climate-Smart Agricultural Practices

MINIMUM	BRONZE	SILVER	GOLD
PRUNING			
All zones			
Formation pruning	Desired formation pruning		
Once a year structural pruning			
3x sanitary pruning	Regular sanitary pruning	Throughout the year sanitary pruning	
Transformation zone			
Formation pruning	Desired formation pruning	Intensive formation pruning	
FERTILIZER APPLICATION			
All zones			
Recommended 3-bag inorganic (fallow period every 5th year)			
	Organic fertilizer		
		Additional inorganic but dependent on soil or leaf analysis	
HARVESTING			
All zones			
2-3 week intervals			
POST-HARVEST HANDLING			
All zones			
6-7 day fermentation, twice turning			
Placenta inclusive			Without placenta
STORAGE			
All zones			
Dry and aerated storage			
		Secured storage	

Topic 4: Crop Management

ADDITIONAL INFORMATION

Pruning

Pruning is necessary **to allow enough light and air** in the cocoa farm, in addition to ensuring proper partitioning of nutrients for growth and pod development. As the climate becomes wetter, hotter and drier, or hotter and more humid, a **more structured pruning approach** in which pruning needs to be adapted to suit every condition. Pruning should be done when rainfall is high to ensure stronger trees that recover faster. In the Transformation Zone the **intensity and frequency of pruning** should be moderated to avoid exposing primary branches and trunks to the direct impact of the sun. **Regular pruning** should be carried out to improve ventilation and avoid trapping of heat in the system. Remove low lying branches to ensure that the first point of branching of the stem is at least 1.5m above the ground.

See also Manual for Cocoa Extension in Ghana: Chapter 3.5 on Pruning.

More information

Fertilizer application:

See also Manual for Cocoa Extension in Ghana: Chapter 3.9 on Productivity enhancement operations.

Harvest:

See also Manual for Cocoa Extension in Ghana: Chapter 3.12 on Good harvesting and post-harvest management practices, part I on Harvesting.

Post-harvest handling:

See also Manual for Cocoa Extension in Ghana: Chapter 3.12 on Good harvesting and post-harvest management practices, part III on Methods on fermentation.

Drying:

See also Manual for Cocoa Extension in Ghana: Chapter 3.9 on Productivity enhancement operations part IV on Drying.

Storage:

See also Manual for Cocoa Extension in Ghana: Chapter 3.13 on Cocoa quality and its estimations.

Topic 4: Crop Management

GUIDELINES FOR TRAINERS

Materials needed:

- ☑ Printed copy (preferably in color) of the 4 drawings depicting intensified rainfall, temperature change, drought, and prolonged dry season.
- ☑ Printed copy (preferably in color) of the 6 drawings depicting pruning, fertilizer application, harvesting, post-harvest handling, drying, and storage.
- ☑ A picture, drawing or a real solar dryer
- ☑ A picture, drawing or a wooden box to ferment cocoa

Time needed:

90 minutes

Preparations:

- ☑ Carefully read the fact sheet, additional information, climate-smart agricultural practices, and guidelines.

Set up

Attention:

Say that crop management includes all agricultural practices used to improve the health, development, and yield of your cocoa.

Title:

Tell the title of the session: Crop management.

Objectives:

To discuss how intensified rainfall, temperature change, drought, and prolonged dry season will affect our pruning, fertilizer application, harvest, post-harvest handling, drying, and storage, and what we should do to mitigate the negative effects.

Benefits:

Our yields mainly depend on how well we manage our crops. Climate change can reduce our yields significantly. If you know how to handle pruning, fertilizer application, harvest, post-harvest handling, drying, and storage in a changing climate, you can avoid reduction of your yield and avoid reduction of the quality of the beans.

Direction:

Although pests and disease management is part of crop management, we will not discuss it, because we discussed that in topic 3.

Delivery

Explanation, Demonstration, Exercise, and Guidance:

1. Ask for **four volunteers**. Ask them to come to the front of the group. Give each of them a **visual** depicting either *intensified rainfall, temperature change, drought,* or *prolonged dry season*. They should hold the visual in front of them, so everyone can see them clearly. When you give each volunteer the visual, **tell clearly** what it depicts.

2. Say that we have seen how climate change can affect the occurrence of pest and diseases and our cocoa farm in general and during the establishment phase. We will now look what the effect of climate change is on pruning, fertilizer application, harvest, post-harvest handling, drying, and storage. We will discuss two together and the other four will be done in groups.

3. Show the visual of ***fermentation***. Ask: *Why is proper fermentation so important?* If beans are not properly fermented, it will have a negative effect on the flavor and quality of the bean.

4. Stand next to the person with the visual depicting ***drought***. Ask him/her to remind the audience what climate change his/her visual depicts. Ask the audience (so not the person carrying the visual): *What will be the **consequences of intensified rainfall** when we **ferment** our cocoa?* Collect answers from several people (see fact sheet for correct answers). Ask the same question for the other climate changes (temperature changes, drought and prolonged dry season).

5. Say that instead of the normal fermentation process (with plantain leaves), we can use wooden boxes or similar devices that prevent reducing or damaging the flavor attributes of the beans. **Show the visual of the wooden box** and explain how it is designed (with holes in the bottom).

6. Continue with the drying of cocoa. Show the visual of ***drying cocoa***. Ask: *Why is the proper drying of beans so important?* If your beans are not properly dried, the **risk of mould is higher** and will **reduce the quality of the beans**, which can lead to less money for your beans in case they are refused by the buyer.

7. Stand next to the person with the visual depicting drought. Ask him/her to remind the audience what climate change his/her visual depicts. Ask the audience (so not the person carrying the visual): *What will be the **consequences of drought** when we **dry** our cocoa?* Collect answers from several people (see fact sheet for correct answers). Ask the same question for the other climate changes (intensified rainfall, temperature changes, and prolonged dry season).

8. Then ask:

    a. *What should we do when we dry our beans when there is more sun and it is warmer?* You need to be careful that the beans will not burn and lose quality. You might want to consider a light shade net to protect the beans from the harsh sun.

    b. *What should we do when we dry our beans when it is wetter and more humid?* Because it will be more difficult to properly dry the cocoa, you can look at alternative ways to dry your cocoa, for example using solar dryers. Add that you will explain this later.

    c. *What should we do when we dry our beans when it is colder?* It will be more difficult to properly dry the cocoa. You can look at alternative ways to dry your cocoa, for example using solar dryers.

9. Say that with irregular weather patterns, such as less predictive rain, it will be more difficult to dry your cocoa in the proper way. You can avoid this by looking at alternative ways to dry your beans, for example solar driers. **Solar dryers** are devices that use **solar** energy to dry substances, especially food. Ask: *Has anyone of you ever seen a solar dryer?*

10. Show the solar dryer (or drawing or picture) and explain how it works. A simple solar dryer is made out of wood and clear plastic. Drying should take place **slowly**. If the beans are dried too quickly some of the chemical reactions started in the fermentation process are not allowed to complete their work and the beans are **acidic** with a bitter flavor. However, if the drying is too slow, **molds and off-flavors** can develop. Various research studies indicate that bean temperatures during drying **should not exceed 65 degrees Celsius** (source: ICCO). On the internet are several examples showcasing dryers for cocoa.

11. Say that we will do an **exercise** to discuss the **effects of climate change** on the four other aspects of crop management: pruning, fertilizer application, harvest, and storage, and **advice on how to deal with the negative effects**. Let the volunteers keep the 4 visuals depicting *drought, intensified rainfall, temperature change,* and *prolonged dry season*. Ask them to stand in different corners (or different places in case you are in the field). Divide the rest of the participants into **4 groups** (you can let every participant choose a crop management practice, just ensure participants are equally divided over the four groups). Give every group one **visual** depicting a crop management practice and clearly tell them what practice they will be discussing.

    The groups should go to the person holding the visual depicting the climate change they will be discussing. They need to discuss: *What will be **the effect** of that particular climate change to your crop management practice and what should we advise other farmers to deal with this?* For example: what is the effect of temperature changes (higher and lower temperatures) on harvesting? Say that the person holding the visual depicting the climate change, can join the discussions. Let the groups discuss and walk around to guide and assist participants.

12. Give the following instructions to the following groups:

    a. **Pruning group:** they should think about the effect of sun and rain on trees and branches (for example, is it good to expose them to burning sun, and will they grow quicker or slower when there is lots of rain), and how pruning could help to reduce effects or even make it worse. They should formulate an advice for every type of climate change.

    b. **Fertilizer group:** they should keep in mind that fertilizers need moisture to be taken up by the roots. They should formulate an advice for every type of climate change.

    c. **Harvesting group:** they should think about how long it will take pods to mature and diseases effecting the pods when they are ready for harvesting. They should formulate an advice for every type of climate change.

    d. **Storage group:** they should think about the effect of heat or humid on stored products. Will there be more pests and diseases, or mold? They should formulate an advice for every type of climate change.

13. **Allocate** every group to one of the climate changes:

    a. Pruning to drought.
    b. Fertilizer application to intensified rainfall.
    c. Harvesting to temperature changes.
    d. Storage to prolonged dry season.

The groups should go to the person holding the visual depicting the climate change they will be discussing. They need to discuss: What will be the effect of that particular climate change to your crop management practice and what should we advise other farmers to deal with this? For example: what is the effect of temperature changes (higher and lower temperatures) on harvesting? Say that the person holding the visual depicting the climate change, can join the discussions. Let the groups discuss and walk around to guide and assist participants.

Note for trainer: This will not be an easy exercise for all groups. The most important is that they should really think about how climate change will affect a certain crop management practice and that you can take action to reduce the negative effects. When you see that groups are a bit lost, give them some ideas to help them on their way.

14. When you notice that the discussions are **fading** (it is not necessary that all groups have concluded their discussions), tell all the groups **to rotate**. That means:
    a The pruning group will move from drought to intensified rainfall.
    b The fertilizer application group will move from intensified rainfall to temperature changes.
    c The harvesting group will move from temperature changes to prolonged dry season.
    d The storage group will move from prolonged dry season to drought.
15. Let groups again **discuss the effects** on their crop management practice. When discussions are fading, rotate again, and after new discussions, rotate one last time (meaning: all groups have "visited" and discussed all climate changes).
16. **Discuss the results per climate change** (so not per crop management practice). Start with intensified rainfall. Ask everyone (including the volunteers holding the other climate changes) to gather around the person holding the visual with *intensified rainfall*. Let the pruning group **present** how intensified rainfall will affect pruning and what they advise farmers to reduce the negative effects. Ask **other groups** if they agree or if they want to add anything. **Add information** if necessary. Continue with the fertilizer application group, then harvesting group and finally the storage group. Before you move the next climate change (temperature change), summarize what farmers should do in terms of pruning, fertilizer application, harvesting, and storage.
17. Move to the **next climate change** and discuss in the same way.

    Note for the trainer: you will need some time to discuss all results. Ask some questions to make the presentation of the results more interesting and to involve all groups.
18. After all discussions, thanks all climate change volunteers and the groups for the work.

Finish

Summary:

Repeat the most important advice for pruning, fertilizer application, harvest, post-harvest handling, drying, and storage.

Questions:

Ask if anyone has a question or comment.

Evaluation:

Ask the following questions:

- Should we prune more or less when the climate is getting hotter and drier? Why?
- What should we keep in mind when we apply fertilizer in a climate with more heavy rainfall?
- What should we do when storing cocoa in a dryer climate?
- How can we avoid that our cocoa won't dry enough in a more humid climate?

Next step:

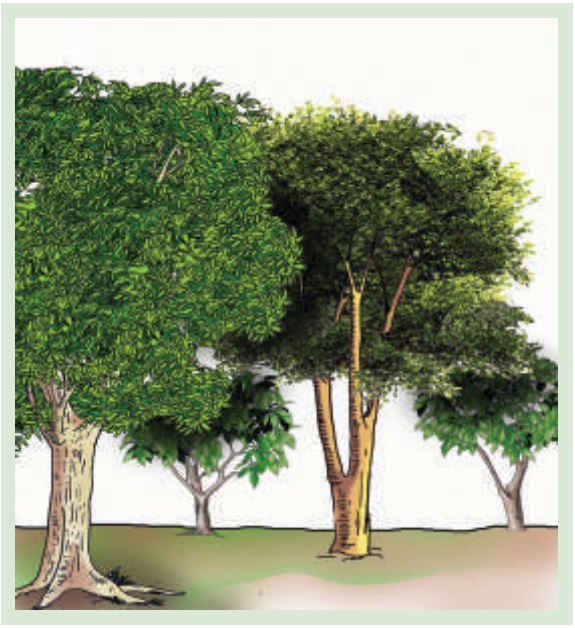
We have seen that a change in climate will affect every aspect of our cocoa farming practices. When you go back to your farm, be aware of changes in climate and take the proper action.

Shade Tree Management

FACT SHEET

How does climate change impact tree management on a cocoa farm?

Shade trees and their management is beneficial, irrespective of the climate, because a correct number of well managed trees with the appropriate canopy area from the right species can help **to protect the farm from excessive sun, harsh winds and strong showers** by serving as a **natural barrier**. Leaves will **enrich the soil** when they drop and protect cocoa trees from direct sunlight so there will be **less evaporation** from the soil and leaves. Shading the cocoa both **prolongs the economic life** of the trees and **reduces the amount of external nutrients** needed.



Planting high, strong trees with a deep root system to protect your cocoa from windstorms and thunder

However, it is important to **manage your shade trees well**, because **excessive shade** can create a **more humid microclimate** on the farm, thus creating more favorable conditions in particular for fungal diseases. In addition, excessive shade will **deprive** cocoa trees of sunlight, which can lead to a reduction in cocoa productivity.

Climate change can result in increased temperatures, changes in rainfall and wind patterns often negatively affecting the microclimate on your farm. To mitigate the negative impact on your cocoa, it is advised to spend **extra care** on your shade tree management. Depending on the climate zone, you will need to plant the **appropriate number and species** of shade trees, and prune accordingly (see topic 4 on Crop management).

Canopy cover

The **number of shade trees** planted per unit area, and the **age** and the **size** of the canopy area determine the amount of canopy cover. Generally, the **warmer and drier** the climate, the **more canopy cover** you will need to reduce the impact of climate change, keeping in mind that excessive shade should be avoided and that the correct species is also important to take into consideration. The amount of recommended canopy cover ranges from **30-50% of the farm** across the different impact zones and adaptation levels, which may correspond to between **18-50 trees per hectare** depending on the species, the age and canopy area.

Type/species of shade trees

There are several types of shade trees, each with their own traits which can either be beneficial to cocoa growing or pose a challenge one needs to take into consideration. It is advisable to keep at least 5 different types of shade trees compatible with cocoa. The following **traits** of shade trees have been observed to be **beneficial** for your farm:

- **Leaf shedding pattern**: Trees shed their leaves at different periods of the year. Especially in hotter and drier climates or with heavier rainfall, it is important to plant different types of trees that **shed their leaves at different periods** of the season to ensure a constant canopy. Because shade cover is most relevant for cocoa in the dry season, it is important to include tree species that maintain their leaves in the dry season instead of those that shed their leaves. Thus, a combination of semi-deciduous and evergreen species should be considered to regulate solar radiation and heat in the dry season when shading of cocoa is most relevant. Examples are *Terminalia ivorenses* and *T. superba*. You can also include species that shed their leaves early in the dry season and grow new leaves during a greater part of the dry season. Examples include Wama (*Ricinodendron heudelotii*), Prono (*Mansonia alttissima*), and Odum (*Milicia excelsa*).
- **Root system:** Some trees have deeper root systems than others. Far reaching roots will reduce erosion and can reach nutrients that cannot be reached by cocoa trees, thereby recycling nutrients and avoiding competition. A strong root structure will avoid that trees are uprooted with strong winds.
- **Height:** When taking height into consideration, preferable are trees that are able to reach the upper canopy for a sufficient gap between the lower shade canopy and the cocoa canopy.
- **Water tolerance:** In riparian zones (nearby water sources), it is recommended to use water tolerant native species to provide shade to enhance ecosystem services (moderate soil and air temperatures, retain soil moisture, create a conducive microclimate).
- **Span and thickness of the crown:** Some trees have a wide crown while others a small span. For example, *Terminalia* has a wide crownm while *Newbouldia laevis* has a small, round crown.

Recommended trees for transformation zone

Canopy species retained or included in cocoa in this zone should have the appropriate traits including self-pruning of branches as well as trees species that maintain their leaf cover in the dry season. Preferred examples are Akuokuonisua, Akye, Awiemfoasamia, Edinam, Nyame dua, Pampena, Mahogany, Odum, Ofram, and Otie. The traits described here are most important for the transformation due to extended dry seasons, drought, and high temperatures but it would also apply to other zones where those impacts/risks are a problem.

Selection of good shade trees

Maintaining an optimal shade level is important for a healthy and productive crop. For young and mature cocoa, shade levels should not be less than 30%-50% depending on the condition on the farm and should be adjusted upwards depending on local condition of the farm. Young cocoa requires higher levels of shade of around 50-70%.

When selecting shade trees the following criteria should be considered:

- Not be a potential host to pests and diseases that can damage the cocoa.
- Have strong and long roots so it can reach nutrients that cannot be reached by cocoa trees and will not be uprooted with strong winds.
- Have a canopy that will not block the sunlight completely but allow some sunlight through.
- Shed leaves (for improvement of soil fertility).
- Be able to retain water (for improvement of moisture level).
- Be tall enough to allow air circulation on the farm.
- Not shed branches that can damage cocoa trees.

Further information

- Asare, R. 2006. *Learning about neighbour trees in cocoa growing systems - a manual for farmer trainers*. Forest & Landscape Development and Environment Series 4-2006
- Asare R, Asare RA (2008). *A participatory approach for tree diversification in cocoa farms: Ghanaian farmers' experience*. International Institute of Tropical Agriculture, Accra
- www.shadetreeadvice.org
- CanOvaLator App
- Hoogendijk, T. and Gahrs D., 2012, Shade tree guide. Agro Eco / Louis Bolk Institute.

Recommendations for tree management improvements

Planting trees

- *All zones:*
  - Plant shade trees
  - Plant trees as boundary / windbreak for silver and gold
- *Coping and risk zone:* Ranges from 15, 18, 20 to 25 trees per hectare
- *Adjustment zone:* Ranges from 20, 25, 35 to 45 trees per hectare
- *Transformation zone:* Ranges from 25, 30 to 50 (for both advanced levels) trees per hectare

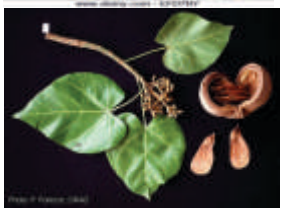
Type of trees

- *All zones:* A combination of semi-deciduous and deciduous species with different leaf shedding patterns for bronze to gold.
- *Adjustment zone (bronze to gold) and transformation zone* (all levels): Include only species with appropriate tree traits.
- *Coping and risk zone:* Terminalia ivorenses and T. superba.
- *Adjustment zone:* Terminalia ivorenses and T. superba; other examples include Yaya (Amphimas pterocarpiodes), Prono (Mansonia alttissima), and Akuokuonisua (Spathodea campanulata) should be considered.
- *Transformation zone:* Akuokuonisua, Akye, Awiemfoasamia, Edinam, Nyame dua, Pampena, Mahogany, Odum, Ofram, and Otie.

Maintenance of trees

- *All zones:*
  - Maintenance pruning for all levels.
  - Structural pruning for silver and gold.
- *Transformation zone:* Include nitrogen fixing plants for a better growth of the trees.

Table: Recommended shade tree species and their main traits

Name	Scientific name	Local name	Traits	Type (service, fruits, timber)	Picture
African ash	*Pterygota macrocarpa*	Kyereye	Self-pruning of branches, maintains leaf cover in the dry season	Timber, medicine	 
African nutmeg / homba	*Pycnanthus angolensis*	Otie	Self-pruning of branches, maintains leaf cover in the dry season, deep root system	Firewood, furniture, medicine	 
African peach	*Nauclea diderrichii*	Kusia	Maintains leaf cover in the dry season. Resistant to fungi and insects	Wood for marine construction	 

Name	Scientific name	Local name	Traits	Type (service, fruits, timber)	Picture
African Tulip Tree	*Spathodea campanulata*	Akuokuo nisua	Self-pruning of branches, maintains leaf cover in the dry season	Flowers for ornamental purposes	 
Albizia	*Albizia ferruginea*	Awiemfoa samia	Self-pruning of branches, maintains leaf cover in the dry season	Timber	 
Cherry mahogany	*Tieghemella heckelii*	Baku/Makore	Self-pruning of branches, maintains leaf cover in the dry season	Furniture, seed oil	 

Name	Scientific name	Local name	Traits	Type (service, fruits, timber)	Picture
False iroko	*Antiaris toxicaria*	Kyen-kyen	Maintains leaf cover in the dry season	Timber, edible fruits, tree bark for dye	 
Ijebu/tiama mahogany	*Entandroph -ragma Angolense*	Edinam	Drops leaf cover in the dry season, shallow root system	Timber, furniture, firewood, medicine	 
Ivory Coast almond	*Terminalia ivorensis*	Emire	Maintains leaf cover in dry season, sheds leaves in Oct-Dec, deep root system	Timber, furniture, firewood	 

Name	Scientific name	Local name	Traits	Type (service, fruits, timber)	Picture
Kumbi	*Lannea welwitschii*	Epro	Self-pruning of branches, maintains leaf cover in the dry season	Timber, furniture	 
Lati	*Amphimas pterocarpiodes*	Yaya	Sheds leaves early in dry season and grows new leaves during greater part of dry season	Timber, medicine	
Mahogany	*Khaya anthotheca*	Krumben	Self-pruning of branches, maintains leaf cover in the dry season, shallow root system	Timber, furniture, firewood, medicine	 

Name	Scientific name	Local name	Traits	Type (service, fruits, timber)	Picture
Mahogany	*Khaya grandifoliola*	Kruba	Sheds leaves during dry season, shallow root system	Timber, furniture, firewood, medicine	 
Mahogany	*Khaya ivorensis*	Dubini	Maintains leaf cover in the dry season, shallow root system	Timber, furniture, firewood, medicine	 
Mansonia	*Mansonia alttissima*	Prono/Bete	Sheds leaves early in dry season and grows new leaves during greater part of dry season.	Furniture	 

Name	Scientific name	Local name	Traits	Type (service, fruits, timber)	Picture
Niagon	*Heritiera utilis*	Nyankom	Self-pruning of branches, maintains leaf cover in the dry season	Timber	 
Odum	*Milicia excelsa*	Odum	Self-pruning of branches, drops leaves in the dry season, shallow root system	Timber, medicine, edible fruits, firewood	 
Ofram	*Tieghemella superba*	Ofram/Framo	Sheds leaves in dry season, shallow root system	Timber, furniture, firewood, animal fodder	

Name	Scientific name	Local name	Traits	Type (service, fruits, timber)	Picture
Red sterculia	*Steculia rhinopetela*	Bima	Sheds leaves early in dry season and grows new leaves during greater part of dry season	Timber, furniture	
Sapele	*Entandrophragma cylindricum*	Sapele	Self-pruning of branches, maintains leaf cover in the dry season (sheds leaves in Oct-Nov), shallow root system	Timber, furniture, firewood, medicine	 
Sinuro	*Alstonia boonei*	Nyamedua	Self-pruning of branches, maintains leaf cover in the dry season (sheds leaves at the end of the dry season), deep root system	Timber, furniture, medicine	 

Name	Scientific name	Local name	Traits	Type (service, fruits, timber)	Picture
Triangle tops	*Blighia unijugata*	Akye	Self-pruning of branches, maintains leaf cover in the dry season	Timber, furniture, firewood	 
Utile	*Entandrophragma utile*	Utile	Self-pruning of branches, sheds leaves in Nov-Mar, deep root system	Timber, furniture, firewood, medicine	 

Not good as shade tree

Name	Scientific name	Local name	Traits	Type (service, fruits, timber)	Picture
African corkwood/ umbrella tree	*Musanga cecropioides*	Odwuma	Not good as shade tree: it gives too much shade and its leaves produce acidic soil, maintains leaf cover in the dry season	Furniture, edible fruit, medicine	 
Cola	*Chlamydocola chlamydantha, Cola chlamydantha*	Osonkrobia, Penamfere, Kra-bise	Not good as shade tree because it hosts cocoa swollen shoot virus, maintains leaf cover in the dry season	Tumber, furniture, firewood, edible fruit	 
Bitter cola	*Carapa procera*	Sua-Bese / Kwakuo-bese	Not good as shade tree because it hosts cocoa swollen shoot virus	Timber, seed oil	  

Name	Scientific name	Local name	Traits	Type (service, fruits, timber)	Picture
Cola	*Cola gigantean*	Watapuo	Not good as shade tree because it hosts cocoa swollen shoot virus and competes for water	None	 
God's heart	*Myrianthus arboreus*	Nyankuma	Not good as shade tree because it hosts cocoa swollen shoot virus, maintains leaf cover in the dry season, deep root system	Edible leaves, edible fruits, medicine	 

Topic 5: Shade Tree Management

Climate-Smart Agricultural Practices

MINIMUM	BRONZE	SILVER	GOLD
Coping and risk zone			
Minimum 15 shade trees per hectare that will provide 30-40% shade cover	Minimum 18 shade trees per hectare that will provide 30-40% shade cover	Minimum 20 shade trees per hectare will provide 30-40% shade cover	Minimum 25 shade trees per hectare will provide 30-40% shade cover
		Trees as windbreak	
	A combination of semi-deciduous and deciduous species with different leaf shedding patterns e.g. Terminalia ivorenses and T. superba.		
	Maintenance pruning		
		Structural pruning	
Adjustment zone			
Minimum 20 shade trees per hectare will provide 30-50% shade cover	Minimum 25 shade trees per hectare will provide 30-50% shade cover	Minimum 35 shade trees per hectare will provide 30-50% shade cover	Minimum 45 shade trees per hectare will provide 30-50% shade cover
		Trees as boundary planting / windbreak	
	Include only species with appropriate tree traits particularly species with a deep taproot system and able to reach the upper canopy for sufficient gap between the lower shade canopy and the cocoa canopy.		
		A combination of semi-deciduous and deciduous species with different leaf shedding patterns e.g. Terminalia ivorenses and T. superba; other examples include yaya (Amphimas pterocarpiodes), prono (Mansonia alttissima), and akuokuonisua (Spathodea campanulata) should be considered.	
Maintenance pruning			
		Structural pruning	

MINIMUM	BRONZE	SILVER	GOLD
Transformation zone			
Minimum 25 shade trees per hectare will provide 50-70% shade cover	Minimum 30 shade trees per hectare will provide 50-70% shade cover	Minimum 50 shade trees per hectare will provide 50-70% shade cover	Minimum 50 shade trees per hectare will provide 50-70% shade cover
		Trees as boundary planting / windbreak	
	A combination of semi-deciduous and deciduous species with different leaf shedding patterns e.g. Terminalia ivorenses and T. superba.		
	Maintenance pruning		
Include only species with appropriate tree traits particularly species with a deep taproot system and able to reach the upper canopy for sufficient gap between the lower shade canopy and the cocoa canopy.			
	A combination of semi-deciduous and deciduous species with different leaf shedding patterns. Canopy species retained or included in cocoa in this zone should have the appropriate traits including self-pruning of branches as well as trees species that maintain their leaf cover in the dry season. Preferred examples are ofram, akye, otie, mahogany, odum, akuokuonisua, awiemfoasamia, edinam and epro.		
Maintenance pruning			
		Structural pruning	

Topic 5: Shade Tree Management

GUIDELINES FOR TRAINERS

Materials needed:

- ☑ None

Time needed:

1.5 hours

Preparations:

- ☑ Carefully read the fact sheet, additional information and guidelines.
- ☑ This topic can be used in addition to topic 3.2 on Shade establishment, 3.5 on Pruning and 3.8 on Soil erosion of the Manual for Cocoa Extension in Ghana.
- ☑ Facilitate this session on a cocoa farm where you can find different types/species of shade trees.
- ☑ For the exercise described at point 5, you need to know which species of trees there are on the farm where you facilitate your session and what traits each of the trees has. You need to prepare very well for this. The Tree Table in this topic and reference materials listed in the fact sheet can assist you.
- ☑ Find out where you can get the trees mentioned for each impact zone and focus during your session on trees that are available in the area.

Set up

Attention:

Point to one of the shade trees (a common one) on the farm and ask what type of tree this is. Say that during this session we will not discuss cocoa trees, but other types of trees we need on our cocoa farm that are beneficial to cocoa production.

Title:

Tell the title of the session: Shade tree management.

Objectives:

To understand how shade trees can help to mitigate the negative impact of climate change on our cocoa farm, and what to look out for when selecting tree species.

Benefits:

Shade tree management is beneficial, irrespective the climate, when the correct number of well managed trees from the right species are planted. If you know how to select and manage shade trees on your cocoa farm, they can play an important role in maintaining a healthy and productive production system in a changing climate.

Direction:

During this session, we will not discuss how to plant or maintain shade trees on your cocoa farm. That will be part of your normal technical training.

Delivery

Explanation, Demonstration, Exercise, and Guidance:

1. Ask everyone to stand around one of the shade trees on the farm. Trees have many **benefits**. We often refer to them as "shade trees" but they offer many more benefits than just shade. Discuss the benefits and let as many different people answer your questions.

    a. Point to the top of the tree and ask: *What type of benefits do leaves have?* Leaves will protect cocoa trees from direct sunlight so there will be **less evaporation** from the soil and leaves.

    b. *What will be the benefits when the leaves drop on the soil?* They will enrich the soil.

    c. *And when there is a heavy rain?* The trees will serve as a natural barrier and will protect the soil.

    d. *And when there is harsh wind?* Also then the trees will serve as a natural barrier.

    e. Point to the soil and ask: *What benefits do the roots have, especially when they are longer than the roots of cocoa trees?* Far reaching roots will **reduce erosion** and can reach nutrients that cannot be reached by cocoa trees, thereby **recycling nutrients**.

    f. *Can anyone mention any additional benefits of trees?* Trees help to **control pests and diseases** because it will reduce the occurrence of capsids (because they like direct sunlight) and will create habitats for predators (especially birds) which can control certain pests, thereby reducing the amount of pesticides the farmer has to use in controlling pest attacks. Shading the cocoa both prolongs the economic life of the trees and reduces the amount of nutrients needed.

    g. *Has anyone observed any negative impacts of trees on cocoa?* Excessive shade can create conditions (humidity) which increases the occurrence of fungal diseases like black pod. This means that we should find a **good balance** of shade canopy and **manage** our trees in a way that they provide benefits to our cocoa production.

2. Say that **climate change** can rise temperatures, change rain and wind patterns, and reduce humidity on the farm. To mitigate the negative impact on your cocoa farm, you need to spend **extra care** on your tree management. Depending on the climate zone, you will need to plant the **appropriate number and species** of shade trees, and prune accordingly.

3. Start with the number of trees. Ask:

    a. *How many trees we see on this farm?* Let people give an estimate.

    b. *On your own farm, do you have more or less trees?* Let several people answer.

4. Say that the number of shade trees planted per unit area, and the age and the size of the canopy area determine the amount of canopy cover. Generally, the **warmer and drier** the climate, the **more canopy cover** you will need to reduce the impact of climate change, keeping in mind that excessive shade should be avoided and that the correct species is also important to take into consideration. The amount of recommended canopy cover ranges from **30-50% per hectare** across the different impact zones and adaptation levels, which may correspond to between **18-50 trees** depending on the species, the age and canopy area. Give the specific recommendations (depending on the zone):

    a. *Coping and risk zone:* Ranges from 15, 18, 20 to 25 trees per hectare that will provide 30-40% shade cover.

    b. *Adjustment zone:* Ranges from 20, 25, 35 to 45 trees per hectare that will provide 30-40% shade cover.

    c. *Transformation zone:* Ranges from 25, 30 to 50 (for both advanced levels) trees per hectare that will provide 30-40% shade cover.

5. Another important aspect of tree management is selecting the right type of trees. There are several types of trees, each with their own traits. In an exercise, we will try to identify species with a specific trait. Start your exercise: Split people into pairs. Mention one of the traits and let people walk around the farm and identify trees with that specific trait. You can look for the following traits:
    a. **Trees that maintain their leaves in the dry season:** Ivory Coast almond, Ofram, Kumbi, African Tulip Tree, wiemfoasamia, Mahogany, Odum, Cherry mahogany, Utile, African peach, False iroko, African ash, Sinuro, Niagon, African nutmeg, Kosipo, Sapele.
    b. **Trees that shed leaves early in the season** and grow new leaves during a greater part of the dry season: Lati, Mansonia, Red sterculia.
    c. **Trees with a deep root system:** Ivory Coast almond, Ofram, Cherry mahogany, Utile, African nutmeg.
    d. **Self pruning:** Kumbi, African Tulip Tree, Wiemfoasamia, Mahogany, Odum, Cherry mahogany, Utile, African ash, Sinuro, Niagon, African nutmeg, Kosipo, Sapele.
6. When discussing results:
    a. Make sure **all groups are involved** (meaning: do not always let the same group answer, you can also mix the groups after every trait).
    b. Clearly mention **the name and local name** of the identified trees. If possible, also mention where farmers can purchase these trees.
    c. Ensure to give **additional information on each trait** as described in the fact sheet and explain why this trait is beneficial.
7. Provide the specific recommendations (depending on the zone):
    a. *All zones:* A combination of semi-deciduous and deciduous species with different leaf shedding patterns for bronze to gold.
    b. *Adjustment and transformation zone:* Include only species with appropriate tree traits particularly species with a deep taproot system and able to reach the upper canopy for sufficient gap between the lower shade canopy and the cocoa canopy.
    c. *Coping and risk zone:* Terminalia ivorenses and T. superba.
    d. *Adjustment zone:* Terminalia ivorenses and T. superba; other examples include yaya (Amphimas pterocarpiodes), prono (Mansonia alttissima), and should be considered.
    e. *Transformation zone:* Ofram, akye, kutre anfro, mahogany, odum, akuokuonisua, awiemfoasamia, edinam and epro.

Finish

Summary:

Repeat all benefits of trees on cocoa farms, and mention the specific recommendations (depending on the zone).

Questions:

Ask if anyone has a question or comment.

Evaluation:

Ask the following questions:

- What type of trees are recommended to plant?
- How many trees should you plant?

Next step:

When you go back to your farm, look at the type and number of trees you already have so you can decide what to do.

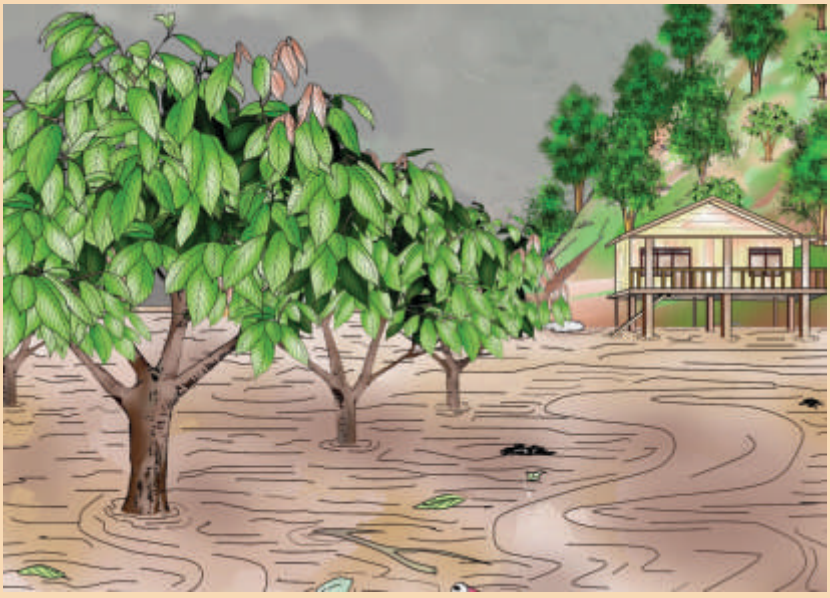
Topic 6

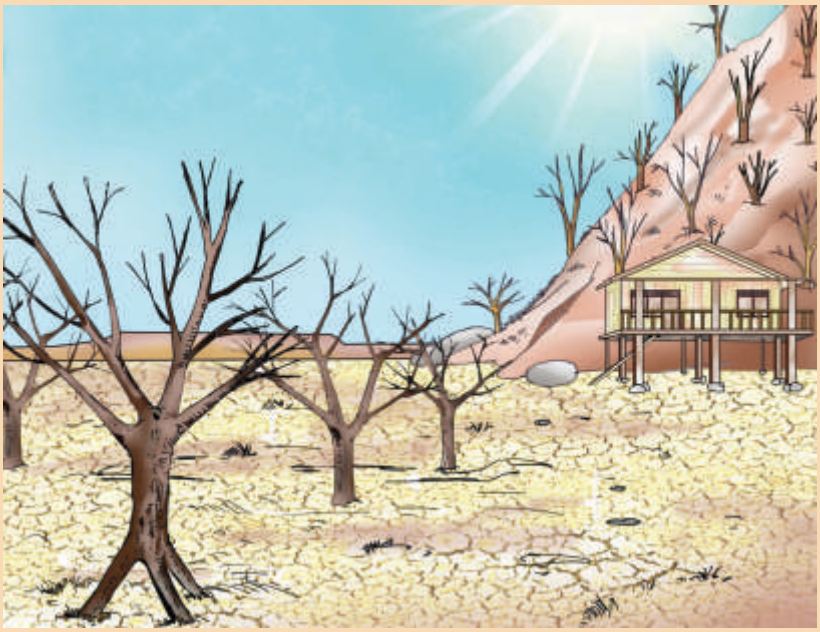
Soil Management

FACT SHEET

How does climate change impact soil?

Cocoa trees need **fertile soil** to grow and produce cocoa pods. Climate change can have a negative impact on soil in several ways.

Zone	Predicted Impact
Coping and opportunity	Climatic conditions are predicted to stay relatively favorable to grow cocoa. However, you need to monitor the conditions of the soil on your farm to avoid nutrient depletion in the soil.
Adjustment zone (systemic adaptation and resilience)	Higher temperatures can decrease the drought tolerance of cocoa and lead to reduced yield due to limited number of flowers surviving to produce pods. Long dry seasons causes moisture stress that also reduces yields. Higher and heavier rainfall can cause erosion, especially on sloping land, and top soil to be washed away thereby reducing soil fertility. In addition, there can be unpredictable changes that can have different effects on the farm. 

Zone	Predicted Impact
Transformation zone	Prolonged dry season, reduction in rainfall, drought. This means will cause severe reduction of yields. 

There is a wide range of soil management interventions, which for example can help reduce the risk of run-off and soil erosion, ranging from field to farm level interventions such as, **cover cropping** during establishment, micro-catchments and surface **mulching**, and landscape level approaches such as **reforestation**. Interventions that improve soil fertility and soil water availability, and reduce the loss of nutrient-rich topsoil through erosion, have the benefit of also improving productivity.

Ground cover

You should use cover crops as a **protective layer** over your soil to prevent heavy rains from washing away the topsoil. Cover crops will also help to **maintain moisture** in the soil. **Intercropping** with leguminous species e.g. *Gliricidia spp*, groundnuts, beans and cowpea, will help to add nutrients to the soil. Cover crops and intercropping is especially important in drought prone regions. Keep in mind that debris left behind after weeding and leaves that drop from the (cocoa) trees can also serve as a protective layer.

Gliricidia spp

Groundnuts

Cowpea

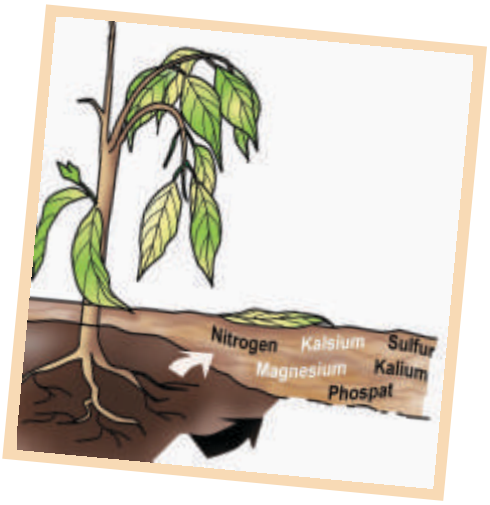
Mulching or composting

Also mulch and compost function as a **protective layer** for your soil and will provide it with extra nutrients. For drier climates, it is recommended to use mulch with plantain pseudo stems (because of the added water) and leaves during the establishment phase to retain soil moisture.

See also Manual for Cocoa Extension in Ghana: Chapter 3.8 on Soil erosion management/Composting.

Soil nutrient analysis

To understand the condition of your soil and what nutrients it might lack, it is advised to carry out a soil analysis, because the conditions on your farm change from season to season any time after harvesting. There are simple **soil kits** on the market that can do a basic analysis (ask your community extension officer). For a more thorough analysis, the soil needs to be sent to a laboratory. In Ghana, the Cocoa Research Institute of Ghana (CRIG), Soil Research Institute of Ghana and the Universities can do soil and folia analysis for cocoa farms. Based on the results of the analysis, you can **adjust your fertilization practices** to avoid wasting money on adding nutrients that the soil does not need and to ensure that you add those nutrients that are needed. This means that your fertilizer practices can change per season and that you no longer can follow the general recommendations.



Nutrient loss

See also Manual for Cocoa Extension in Ghana: Chapter 3.9 on Soil fertility management, Fertilizers and Fertilizer application.

Erosion control

Heavy rains, especially in hotter climates where the soil can be very dry, can cause erosion. To avoid that valuable nutrients are washed away, you can set up **drainage systems**, especially in flood prone areas. For areas with more and unpredicted rainfall, it is recommended to **build trenches** to control excess water. In addition, the selection of **appropriate trees and/or contour planting** can help to manage erosion and floods.

See also Manual for Cocoa Extension in Ghana: Chapter 3.8 on Soil erosion management.


Trenches in a cocoa farm

Recommendations for soil management improvements

Organic matter

- *All zones:*
  - Mulching
  - Composting

Organic matter

- ·*Transformation zone:* Mulch with plantain pseudo stems and leaves in establishment phase to retain soil moisture

Ground cover

- *All zones:* Intercrop with leguminous species e.g. Gliricidia spp, groundnuts, beans and cow pea.
- *Transformation zone:* Cover crop for advanced levels.

Erosion control

- *Coping and risk zone:* Drainage systems for flood prone systems for erosion control for advanced levels.
- *Adjustment and transformation zone:* Trenches to control excess water for all levels.
- *Transformation zone:* Include nitrogen fixing plants for a better growth of the trees.

Soil analysis

- *All zones:* Soil nutrient analysis for advanced levels.

Topic 6: Soil Management

Climate-Smart Agricultural Practices

SOIL MANAGEMENT			
MINIMUM	BRONZE	SILVER	GOLD
All zones			
Mulching or composting		Mulching and composting	
		Soil nutrient analysis	
Coping and risk zone			
	Intercrop with leguminous species e.g. Gliricidia spp, groundnuts, beans and cow pea		
		Drainage systems for flood prone systems for erosion control	
Adjustment zone			
Intercrop with leguminous species e.g. Gliricidia spp, groundnuts, beans and cow pea			
Trenches to control excess water			
Transformation zone			
Intercrop with leguminous species e.g. Gliricidia spp, groundnuts, beans and cow pea			
		Cover crop	
Mulch with plantain pseudo stems and leaves in establishment phase to retain soil moisture			
Trenches to control excess water			

Topic 6: Soil Management

ADDITIONAL INFORMATION

There are many **advantages** of planting **cover crops**.

Prevent Erosion

Soil that is exposed to the elements is at a greater risk of erosion by wind and water runoff. This can mean the **removal of the rich topsoil** and the compaction of the soil underneath, making planting much difficult and crop development impossible due to **loss of nutrients**. Cover crops help to stabilize the soil, prevent runoff and increase nutrient availability.

Improve Soil Structure

The **roots** of cover crops help to improve the **structure of the soil**. The **foliage** of the plants helps to prevent compaction of the soil by **protecting** it from rain, erosion and, in some cases, livestock. The passages and pore spaces that the roots create allow for **moisture percolation** and **aeration** of the soil, as well as means by which insects and other microorganisms, which are themselves essential to the health of the soil, can move through it.

Organic Matter

Soil is improved by the addition of organic matter. Organic matter helps **stimulate microorganism** activity, gives **nutrients** to the soil, improves the **structure** and helps with **moisture retention**. Cover crops add to the organic matter of the soil when leaves drop to the floor, and when slashed or allowed to die back, when they form a **natural mulch or compost**. Combining cover crops and compost is one of the most efficient ways to maintain soil quality throughout the year.

Suppress Weeds

Cover crops are sometimes referred to as 'living mulches'; one of the reasons being their ability to suppress weeds. The roots of the cover crops **compete** vigorously with weeds for available nutrients, depriving the weeds of the elements they need to thrive. The leaves of the cover crops also compete for light and space above ground, typically **shading out** the weeds so that they cannot photosynthesize effectively. Furthermore, when crops die or are slashed, they perform a more conventional **mulching** function of smothering the weeds and their incipient seeds.

Moisture

Planting a cover crop is an effective way to conserve and even increase the moisture content of the soil. Besides **preventing runoff** by limiting the erosion of the topsoil, the crops do this in two ways. Firstly, by providing a **cover for the soil**, they protect it from evaporation by the sun and the wind. Secondly, many cover crops send down **deep roots**, which can bring up moisture from lower down in the soil profile.

Nutrients

Another benefits that cover crops bring to the soil is **adding valuable nutrients**, such as nitrogen, an essential element that all plants need. Leguminous species have a special ability to **'fix' nitrogen** into the soil. They have nodules on their roots that provide a habitat for certain nitrogen-fixing bacteria. Not only does this increase levels of nitrogen in the soil while the plant is growing, when the plant dies, after harvesting for example, the nitrogen is released into the soil and becomes available for other plants to use. If you are planting a food crop in succession after the cover crop, it will have a **good nutrient load** with which to get started. Cover crops can be periodically slashed and the stems and foliage left to rot in order to release their nutrient load into the soil.

Biodiversity

Growing cover crops adds to the biodiversity of your land. All species of plants have their own unique characteristics, including how they **interact** with other plants (such as providing shade or fixing nitrogen) and organisms (such as attracting beneficial insects, or repelling insects that could damage neighboring specimens). The cover crops can also **attract** wildlife, by providing habitat, feeding opportunities (on insects attracted by the plants, for instance), and protection from the elements and predators.

Insects

This biodiversity is a major part of attracting a wide variety of insects to your plot. By planting cover crops rather than leaving bare earth, you will bring **more species of insect** to your site. Some insects will predate on others and so prevent populations booming which may impact upon your crop yield. Attracting insects also **increases the number of pollinators** on your site. The increased organic matter and nutrients in the soil also feeds beneficial microbes that can keep fungal and bacterial infections in check, and limit the number of nematodes, microscopic organisms that feed on plant roots and stems, and which can carry viruses that they transmit to the plants.

Adapted from https://www.regenerative.com/magazine/10-benefits-cover-crops

Topic 6: Soil Management

GUIDELINES FOR TRAINERS

Materials needed:

- ☑ Mulch
- ☑ 2 buckets with water

Time needed:

45 minutes

Preparations:

- ☑ Carefully read the fact sheet, additional information and guidelines. Look at the specific recommendations in the table with CSA practices to know what to recommended to the group you are training.
- ☑ Facilitate this session on a farm with mulch and compost, and leguminous species as intercrop. For the adjustment and transformation zone, try to find a field with trenches to control excess water.
- ☑ For your demonstration on cover crops/mulch (see point 1 and 7), you need to prepare 2 small plots (1m by 1m each, use some rope to demarcate them). Collect some mulch and put that at the side of the plots.

Set up

Attention:	Point to any of the intercrops and ask what type of crop this is. Ask: *Why was this crop planted here?* Let several people answer. When someone says that it will protect the soil or add nutrients to the soil, you say that the topic we will discuss during this session is the soil on our farm.
Title:	Tell the title of the session: *Soil management.*
Objectives:	To discuss how climate change can impact soil management on our farm, and practices to reduce the negative impact on our soil.
Benefits:	Our cocoa trees need soil to produce healthy pods. If you apply the practices we will learn during this session, you can maintain your cocoa production in a changing climate.
Direction:	During this session, we will not going into detail on fertilizer application or how to make compost: that will be part of your general training program.

Delivery

Explanation, Demonstration, Exercise, and Guidance:

1. Start with your **demonstration**:
   a. Invite participants to your prepared piece of land and ask for two assistants.
   b. Say that we see 2 plots: one we will cover with mulch, while we will leave the other plot uncovered. Ask your assistants to cover one of the plots with mulch. Make sure it is evenly divided over the plot.
   c. Take your buckets with water and say that we will now let it rain on our plot. Ask your assistants to let it rain (meaning: they should not pour the water directly from the bucket on the plots but rather sprinkle it with their hands, 1 bucket per plot).
   d. Thank your assistants and say that we will look at the results later.
2. Cocoa trees need fertile soil to grow and produce cocoa pods. Climate change can have a negative impact on soil in several ways. Ask:
   a *What can happen to the soil when **rains** become **heavier** and/or more **frequent**?* It can wash away the topsoil, thereby removing nutrients.
   b *What effect will a **burning sun or higher temperatures** have on our soil?* It will evaporate the moisture in the soil leaving it dry and cracked, and unable to hold water.
3. Fortunately, there are a few **practices** we can implement on our farm to **minimize the impact** on our soil. Refer to the crop you pointed out when you started the session. Ask:
   a. *If you plant cover crops between the cocoa trees, what will happen with your soil during a heavy rain?* It will not be washed away because it will be **protected**.
   b. *And if you use leguminous types as cover crops?* It will help to **add nutrients** to the soil.
   c. *What type of crops can we use as cover crops?* Leguminous species *e.g. Gliricidia spp*, groundnuts, beans and cowpea.
   d. *In case the climate becomes drier and/or more unpredictable in terms of rainfall patterns, do we need more or less cover crops and intercropping?* We need plant more cover crops and do intercropping.
   e. *Why?* Because when the soil is dry, it will need **extra protection** from the sun against evaporation of water and from the rain to avoid washing away of nutrients.
   f. *What else can we do to protect the soil and to provide extra nutrients?* We can use mulch or compost. We should also keep in mind that debris from weeding can also serve as a protective layer.
4. For everyone we recommend **intercropping**, to either use **mulch or compost**, and to **leave debris from weeding** (maintained at a low level with cutlass). If you want to invest more in your farm, you can **add cover crops** and do **both** mulching and composting. For drier climates, it is recommended to use **mulch with plantain pseudo stems and leaves** during the establishment phase to retain soil moisture.

5. Another way to protect the nutrients in the soil, is to **control erosion**. Ask the group to come to the **trenches**. Ask:
    a. *What is the use of these trenches?* It will control **excess water**.
    b. *When the climate becomes hotter and the soil becomes drier, will there be more or less need to build trenches to manage the rain? There will be more need.*
    c. *Why?* Because in case of rain, the water will not be easily **absorbed** by the soil.
    d. *Where should trenches be built: at the edges of the farm or at point of entry of water in the farm?* The answer will depend on how much water is passing through the farm.
    e. *How do we make the trenches?* You can do it manually. It is not necessary to make the trenches very wide or deep: 2 feet wide (60 cm) to 1.5 feet (45 cm) deep is enough. Make sure to evenly distribute the soil you dig out and not leave it all in one heap next to the trench to avoid that it will be washed back in the trench during a heavy rain.
    f. The selection of **appropriate trees** can help to manage erosion and floods.

Note: The trenches are only for the adjustment and coping zone to reduce flooding, humidity and erosion.

6. Whatever way you protect your soil, you will always **lose nutrients**. Plants for example need nutrients to grow and produce fruit which are then harvested and 'exported' from the plot and no longer contribute to the nutrient cycling. For farmers that have the capacity and opportunity we recommend **soil analysis** either by using a simple soil kit or by sending soil samples to the laboratory for testing. Based on the results of the analysis, you can **adjust your fertilization practices** to avoid wasting money on adding nutrients that the soil does not need and to ensure that you add those nutrients that are needed. This means that your fertilizer practices can change per season and that you no longer can follow the general recommendations.
7. Invite the participants back to the plots where you started your session (see point 1). Remove the mulch. Ask participants what they **observe** when comparing the two plots. In spite of the short period the plots were left, you will observe the following:
    a. The soil on the plot with the mulch will be more moisten than the plot without mulch.
    b. On the plot without mulch, you will see **small gutters** where the water went through (leading to erosion).
    c. Ask what happens when heavy rain will hit both plots: the rain will **not hit directly** the soil on the plot with the mulch, while it will (and damage the soil) on the plot without cover).

Finish

Summary:

Repeat how climate change can affect soil on our farm. Repeat some of the advice (link it to your demonstration).

Questions:

Ask if anyone has a question or comment.

Evaluation:

Ask the following questions:

- What are the advantages of cover crops?
- Which crops would be good cover crops?
- what are the benefits of trenches?

Next step:

When you go back to your farm, see what you can do to manage your soil well.

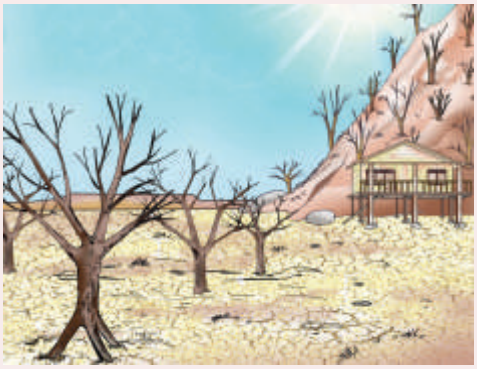
Topic 7

Water Management

FACT SHEET

How does climate change impact water management?

Cocoa trees, and especially seedlings, need water to grow and to produce pods. Climate change can have a negative impact on water in several ways. This means you need to find ways to manage your water carefully.

Zone	Predicted Impact
Coping and opportunity	Climatic conditions are predicted to stay relatively favorable to grow cocoa. However, you need to monitor water sources to avoid depletion and avoid contamination of water sources.
Adjustment zone (systemic adaptation and resilience)	Higher temperatures and absence of trees can cause reduced availability of water. Higher and heavier rainfall can cause an **abundance** of water, even causing flooding. 
Transformation zone	A prolonged dry season, reduction in rainfall, and drought can significantly reduce the water availability on or nearby your farm. When rivers and streams become drier, access to water can become a problem on your farm but also for your household. 

Water harvesting

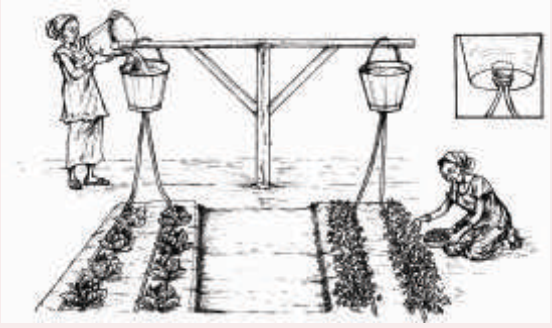
Harvesting rainwater can probably not provide all the water you need on your farm and household but it can help. You can collect your own water at household level or at the farm, but it is also possible to collect **rainwater** with the community. Harvesting can be done by digging ponds nearby the farm or community. When you line the ponds with plastic or bamboo, the water will be better retained, and you can even use the ponds for fish farming. You can also simply place **barrels** outside when it rains, to more sophisticated systems in which rain can **run off** from a large smooth surface (a roof for example) into a roof gutter that is connected with pipes to barrels. You can even connect these barrels to large **water storage tanks** so you can collect much larger quantities. In that case you need a small pump to get the water out of the tank.

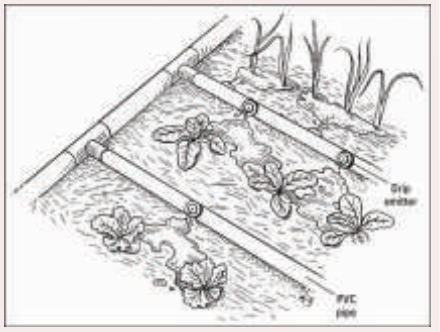
When using barrels to collect water, it is convenient to have a spout at the bottom to release the water. You can connect it to a hose for easy release of water.

Irrigation

Irrigation means adding water artificially to your plants. There are several methods of doing this.

- **Local practices:** Water is distributed across the farm to plants through manual labor and watering cans or plastic bottles. This system is very labor intensive, and the water will be poured on the soil all at once. Especially for dry soil, it is difficult to take up all water and water will be wasted.
- **Improved local innovative irrigation practices:** For example, placing bamboo sticks or bottles filled with water next to seedlings and mature cocoa.
- **Drip irrigation** is a form of irrigation in which through a network of valves, pipes, tubing, and emitters water slowly drips to the roots of many different plants at the time the plants need water. In this type of irrigation, evaporation and runoff are minimized. The installment of an irrigation system is a substantial investment and you will need to maintain the system. It would be possible to construct a simple irrigation system with plastic bottles.





Water conservation

Instead of generating extra water, you can also manage the available water better. We already saw that shade trees can help to retain moisture on the farm, e.g. *Spathodea campanulata (Kuokuonisuo)*. In addition, you can manage your soil well for moisture retention (see topic 6 on Soil management).

Handling excess water

Climate change does not always mean a shortage of water; it can also cause an **abundance of water**, leading to flooding. You need to manage the excess of water on your farm to avoid physical damage to the trees, and diseases like root rot and black pod. Proper drainage systems and trenches as described in topic 6 on Soil management can help. It is also important to ensure that trenches and waterways such as rivers and streams, are not blocked by for example empty husks, branches and leaves. You can create a **buffer zone** of at least 5 meters between your farm and any water body on which you will not do any farm activities. You can plant trees in your buffer zones.

Recommendations for water management improvements

Water harvesting

- *All zones:*
  - Household rainwater collection systems for advanced levels.
  - Community or farm rainwater collecting for gold level.
- *Transformation zone:* Mulch with plantain pseudo stems and leaves in establishment phase to retain soil moisture.

Irrigation

- *All zones:* Local practices using plastic bottles as irrigation for different levels per zone.
  Adjustment and transformation zone: Improved local innovative irrigation practices.
  Transformation zone: Drip irrigation for gold level.

Topic 7: Water Management

Climate-Smart Agricultural Practices

WATER MANAGEMENT			
MINIMUM	BRONZE	SILVER	GOLD
Coping and risk zone			
		Household rainwater collection systems	
			Community or farm rainwater collecting
			Local practices using plastic bottles as irrigation
Adjustment zone			
	Household rainwater collection systems		
			Community or farm rainwater collecting
	Local practices using plastic bottles		Improved local innovative irrigation practices
Transformation zone			
	Household rainwater collection systems		
		Community or farm rainwater collecting	
	Local practices using plastic bottles as irrigation	Improved local innovative irrigation practices	Drip irrigation

Topic 7: Water Management

GUIDELINES FOR TRAINERS

Materials needed:

- ☑ Flip-sheets and markers (to draw systems to collect water)

Time needed:

45 minutes

Preparations:

- ☑ Carefully read the fact sheet, additional information and guidelines. Look at the specific recommendations in the table with CSA practices to know what to recommended for the group you are training.
- ☑ Identify a field/place in the community where water is collected to demonstrate this aspect.
- ☑ For the adjustment and transformation zone, try to find a field with trenches to control excess water.
- ☑ For more advanced farmers, it would be good to show water collection and irrigation systems. Or you can make drawings as depicted in the fact sheet.

Set up

Attention:

Point to the water collection and ask what is being done here: water is being collected. Say that water collection is one of the points we will be discussing during this topic.

Title:

Tell the title of the session: *Water management.*

Objectives:

To discuss how climate change can impact water management on our farm and ways to manage the shortage but also excess of water on the farm.

Benefits:

Our cocoa trees need water to produce healthy pods. If you apply the practices we will learn during this session, you can maintain your cocoa production in a changing climate.

Direction:

During this session, we will discuss water management on the farm specifically linked to climate change. We will not discuss the handling of wastewater after rinsing equipment used for pesticide application or water management in your household, although some ideas on water collection might be used for that purpose as well.

Delivery

Explanation, Demonstration, Exercise, and Guidance:

1. Climate change will influence the access to water on our farm. Ask: "*How can the following changes influence water on our farm?* Collect answers from different participants.
    a. **Higher temperatures:** This can reduce the availability of water because water will evaporate quicker.
    b. **Higher and heavier rainfall:** This can cause an **abundance of water**, even causing flooding.
    c. **Prolonged dry season, reduction in rainfall and drought:** This can significantly **reduce** the water availability on or nearby your farm. When rivers and streams become drier, **access** to water can become a **problem** on your farm but also for your household
2. This means there can be a **shortage** of water but also an **abundance** of water. One way to avoid a **shortage of water** is to **harvest** it. Ask:
    a. *Does any of you or anyone in your community harvest rainwater on the farm, at the house, or in the community?*
    b. In case someone does, ask: *How?* You can ask the person to draw the system on the flip-sheet to visualize it.
    c. *Do we know more methods of harvesting water?* **Show the drawings** of the rainwater collection and explain the different ways to collect rainwater.
3. In case the climate gets drier and less rain will fall, we can use **irrigation** to artificially add water to our farms. Ask: Does any of you has any type of irrigation system on your farm? If yes: How? Say that there are several methods to add water to your farm. Explain the practices as described in the fact sheet and show them as much as possible in reality or by using a drawing. Say that the **drier** the climate, the more the **need** for irrigation. Depending on your willingness and capability to **invest** in your farm, you can select a more **sophisticated** system.
4. Say that instead of generating extra water, you can also **manage the available water better**. Ask all participants to stand up. They need to **form pairs** with someone who is of approximately the **same age**. Every pair needs to discuss how we can manage the available water better. Give a few minutes (not too long) for the discussions. Then tell everyone to find another partner; this time they need to find someone who is either **much older or much younger**. Again, each pair needs to discuss ways to manage available water better.
5. **Discuss the results**. Let every pair give you one idea. Add information from the fact sheet if necessary.
6. Say that climate change does not always mean a shortage of water; it can also cause an **abundance of water**, leading to flooding. We need to manage the excess of water on our farm to avoid physical damage to the trees, and diseases like root rot and black pod. Ask what we have discussed during the previous session on soil management to manage an abundance of water: **trenches**. Say that it is also important to ensure that trenches and waterways such as rivers and streams, are not blocked by for example empty husks, branches and leaves. Ask: What can we do to avoid blockage of water ways and trenches? You can create a **buffer zone** of at least 5 meters between your farm and any water body on which you will not do any farm activities.

Finish

Summary:

Repeat how climate change can affect water on our farm. Repeat some of the advice.

Questions:

Ask if anyone has a question or comment.

Evaluation:

Ask the following questions:

- How can we collect rainwater?
- How can we conserve water?
- How can we handle an abundance of water?

Next step:

When you go back to your farm, see what you can do to manage your water well: see how you can collect water, how to better manage the water that is available, and check if waterways are not blocked.

Topic 8

Increasing Resilience

FACT SHEET

Planning

There are many factors that **impact your farm** that go **beyond** the activities that you implement at plot or farm level. For example, the price for cocoa or agrochemical inputs, rules and regulations that are dictated by the government, the availability of planting materials, and availability of training or new technologies. Although it is **difficult to influence these factors** yourself, it is important to realize that they will affect you and your farm. In addition, all these factors will be influenced by climate change and can therefore create extra challenges. To ensure that you are ready to cope with **these extra challenges**, you will need to increase your level of **resilience**. Resilience is the ability to bounce back from difficulties, for example a climate shock or negative impact.

To increase your resilience, you should look beyond your normal day-to-day farming activities. The following aspects could be taken into consideration:

1. Diversification
2. Natural Resource Management (NRM)
3. Farm planning
4. Quality control
5. Insurance
6. Other aspects

1. Diversification

In a changing climate, it is predicted that growing cocoa in certain regions will become more difficult or even impossible in the near future. Especially in regions with higher temperatures, reduced rainfall, prolonged dry season, and drought (i.e. **transformation zone** as described in topic 1), the negative impacts to cocoa production will **be significant**. To minimize the risk of this happening, it is important to **plan ahead** and explore additional sources of income that can support your household. **Diversification** means to include **other ways of income** in addition to your cocoa farm, so you are no longer dependent on one crop only, in this case cocoa, which will make you less vulnerable when something happens to that crop.

One way to diversify your source of income, is by planting **other cash or food crops** with your cocoa. As the climate becomes more challenging to grow cocoa, you can consider planting more varieties such as plantain and black pepper for example.

Another strategy might be **to plant additional shade trees** with economic value that will not only provide you with all the biophysical benefits trees bring to your cocoa farm (see topic 5 on tree management), but in addition can provide you with **other income sources** such as edible fruits, timber, firewood, medicine, seed oil, or animal fodder. Here are some tree examples that add value:

- ***Allanblackia*** is a tree which has all general advantages and in addition, oil can be made from the seeds and sold on the international market. It grows primarily in tropical rainforests, but can be cultivated on farmlands. If you would like to plant this tree, please contact your community extension agent because research suggests that this tree can be a host for some pests and therefore needs to be managed and monitored well.



Allanblackia tree, fruits and leaves

Terminalia sp is known for the value of its bark which is used for medicinal properties. *T. superba* occurs in moist evergreen forest, moist semi-deciduous forest, and dry semideciduous forest. It is deciduous and performs well in intermediate soil fertility but shows no preference for wet or dry soils, especially in Ghana. Its growth declines when there is a decrease in rainfall. *T. ivorensis* occurs in evergreen forest and moist semi-deciduous. It prefers moist conditions, but does not show any preference for wet or dry forest soils and is not drought sensitive. Its decreases with poor soil fertility.

Terminalia ivorensis

Terminalia ivorensis leaves


Terminalia superba tree and leaves

Prunus africana is used traditionally for timber, fuel-wood and medicine. It is also a raw material for the pharmaceutical industry. The *P. africana* requires a moist climate, 900–3,400 mm annual rainfall, and can tolerate frost up to a moderate level. It is a light-demanding, secondary-forest species.

Cashew is suited very well in zones where cocoa production will become a serious challenge due to rising temperatures and drier conditions. It can be planted within cocoa. Cashew requires **high temperatures** and does not tolerate frost. It grows well in **warm and humid areas**. It can thrive under an annual rainfall of 500-3500 mm rain per year, and a mean annual temperature of 20-35°C. It grows well under one rainfall season or two rainfall seasons in a year, but the **distribution of the rainfall is important**; too much rains during flowering can lead to decrease in fruit yield and the fruits need dry weather to ripen. It can grow well on a wide range of soils but prefers lighter, fertile soils. It is a light-demanding crop.

Another way of diversification is to start **an alternative livelihood enterprise** such as bee keeping, small mammal rearing such as grass cutters or similar. In case you are interested in setting up these type of enterprises, you can contact your community extension agent for more information.

Recommendations for diversification

Diversification

- *All zones:*
  - Ground cover or lower canopy species such as black pepper and similar for different advanced level.
  - Alternative livelihoods enterprise such as bee keeping, grass cutter rearing, etc. for advanced level.
- *Adjustment and transformation zone: for advanced levels.*
  - Cocoa (3x3m) plus black pepper and others.
  - Cocoa (3x3) -plantain (interspaced) - Terminalia spp (20m) - Integrate Allanblackia and other multi-functioning tree crops.
  - Cocoa (3x3) plus prunus africana (10x10m).
- *Transformation zone: for silver and gold.*
  - Grafted cocoa (2x2) - cashew (10m distance).
  - Switched over from cocoa to cashew and/or other more climate and soil suitable crops as diversification.

2. Natural Resource Management (NRM)

Natural resource **management** refers to the management of **natural resources** such as land, water, soil, plants and animals. **Deforestation** and the **destruction of watersheds** as a result of widespread illegal mining, over-logging, and the conversion of forest to agriculture are among the many environmental challenges that can further negatively impact the production of cocoa. The **absence of a riparian buffer** for example could mean that basic but vital ecosystem services (such as the protection of water catchments and the control of erosion of vulnerable soils and slopes) are lost. A changing climate might not only negatively impact your cocoa but also the **environment and biodiversity** on and around your farm which are crucial to the existence and health of your cocoa.

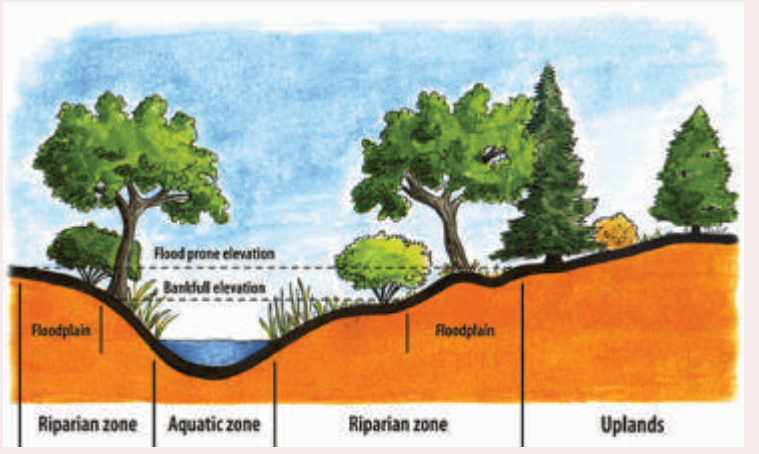
Here are a few steps that can help you to reduce the risk from those challenges:

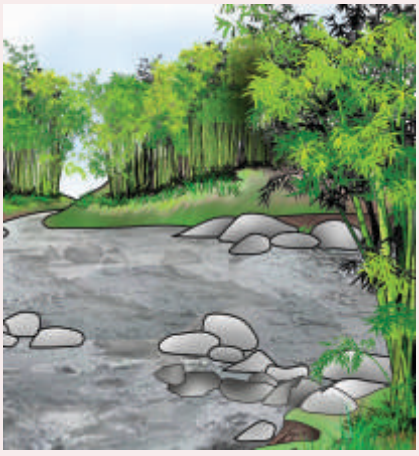
- In a drier climate, **bushfires** will become more common. To protect your farm and community from bush fires you can prepare a **fire management plan**. Such a plan can include creating fire belts around your farm, having equipment to fight fires at hand (buckets with sand), ensuring that equipment (such as chainsaws and mist blowers) does not give sparks, etc.

Fire belt around a farm

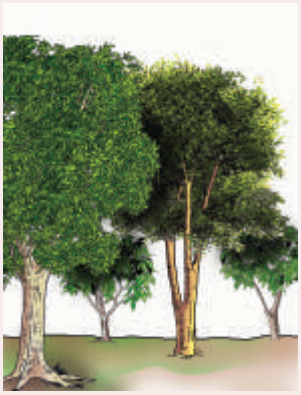
Buckets with sand

- Cocoa farms in landscapes where the riparian cover is destroyed will show **less resilience** to climate change compared to landscapes where the ecosystem services of riparian areas are conserved. In **riparian zones** (the area between land and a river or stream), you can provide shade by planting **water tolerant native species**, such as *Triplochyton scleroxylon* (Wawa). They will enhance ecosystem services such as moderate soil and air temperatures, retain soil moisture, create a conducive microclimate. Be aware that some species, including Eucalyptus, take up a lot of water, resulting in drying up of water bodies.





- You should **conserve wildlife habitats** for the purpose of biological control of cocoa pests. To be able to do this, the first step is to **learn about endangered species** in your area and understand which of them are useful in controlling pests and diseases. Your wildlife officer can assist you in this. Another step is to make your farm more **wildlife friendly**, for example by not leaving garbage on your farm that can be dangerous for wildlife when they eat it (such as plastics) and not placing any traps on and around the farm. It is also important to **provide food and shelter** for wildlife, for example by preserving water bodies (by not polluting them), preserving insects and other animals that can serve as food, and preserving trees on and around your farm. You should also avoid application of pesticides that can be harmful to wildlife.
- **Restore shelterbelts**, a line of trees or shrubs planted to protect an area, especially a field of crops, from extreme weather events such as strong winds or heavy rains.



- **Restore the forest cover** which indicates the density of the tree canopy on your farm (see topic 5 on tree management).
- Not only you but also **your community** can be mobilized in preserving natural resources. You can discuss within your community how to protect your land from illegal mining, restore forest cover of degraded shelterbelt and headwater forest reserves (forest that protect sources of rivers and other water bodies).
- Instead of separate actions as listed above, you can also prepare a **landscape or watershed** management plan in which you will list what the current situation is, the changes you expect, and the actions you can take to mitigate the impact. This plan should be made at the community level.

Recommendations for natural resource management

- *All zones: Fire management plan for advanced levels.*
- *Coping and risk zone: Landscape or watershed management plan for gold.*
- *Adjustment and transformation zone:*
  - Provide shade in riparian zones using water tolerant native species to enhance ecosystem services (moderate soil and air temperatures, retain soil moisture, create a conducive microclimate) for cocoa for bronze.
  - Mobilize community action to restore forest cover of degraded shelterbelt and head water forest reserves in the cocoa belt for advanced levels.

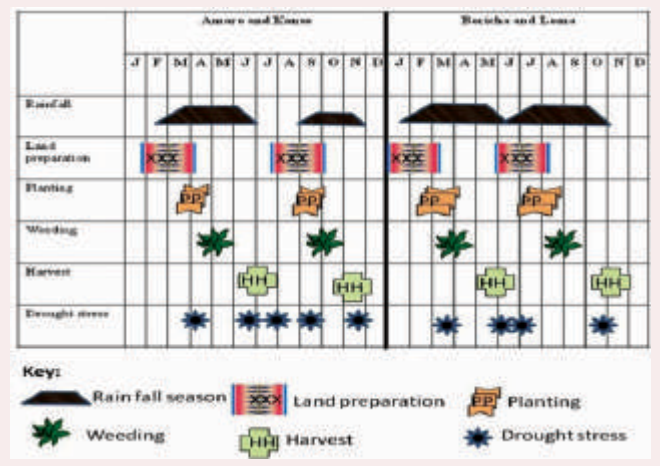
3. Farm Planning

Irrespective the impact of climate change on your cocoa, you can prepare yourself much better if you **know the situation on your farm**. A few activities will help you with that, including:

- **Land title documentation and registration:** If you want to manage your farm well, you should be the person who can take decisions on how to manage it.

- **Registration of trees on your farm:** Trees play an important role in strategies to adapt to climate change. To protect them and make the most of them to mitigate negative impact of climate change, you need to be the person who can decide how to manage the trees on your farm. Currently, Ghana is working on a system in which you can register the trees on your farm, which will allow you to take decisions on how to manage your trees and for example sell them as timber when they are grown.

- **Development of a cropping calendar:** depicts the period in which farming activities are done. If you know what activities need to be done during what period you can better plan towards this. For example, you can ensure that certain equipment or inputs are available when you need them.



- **Mapping of your farm**, preferably with GPS coordinates: Mapping of farms will give you an exact idea how large your farm which can help you to better plan when you would like to replant trees, purchasing and applying fertilizer or other inputs to avoid any waste, or estimate your yields. It also helps to better understand the situation on your farm as you can better plan for example how to protect vulnerable areas on your farm and where to dig trenches or plant trees.

Recommendations for farm planning

- *All zones:*
  - Land title registration for silver and gold.
  - Development of cropping calendar for silver and gold.
- *Coping and risk, and transformation zone: for gold.*
  - Land title registration
  - Development of cropping calendar
- *Adjustment zone:*
  - Simple farm map (with/without GPS coordinate) for bronze.
  - GPS mapping of farm for silver and gold.
  - Land title registration; Registration of trees on farm; Farm development plan for silver and gold.

4. Quality Control

With irregular weather patterns, such as less predictive rain, it will become **more difficult to dry your cocoa** in the proper way. If your beans are not properly dried, the **risk of mold contamination** is higher. This can **reduce the quality** of the beans which in turn can lead to a **loss in earnings** as inferior quality won't achieve the same price as higher quality beans. You can avoid this by looking at **alternative ways to dry your beans**, for example solar dryers (see topic 4 on Crop management).

5. Insurance

Although it is not available yet in Ghana, another way to safeguard yourself and your family for severe consequences of climate change, in addition to actions you can take to mitigate the effects, is to get climate risk insurance, e.g. yield insurance. With yield insurance you get compensated when you lose (part of) your yield due to unforeseeable conditions, such as the weather. At the time of writing this manual, this option is not yet available in Ghana but significant progress is being made towards yield insurance.

Recommendations for insurance

- *All zones:*
  - Climate risk insurance e.g. yield insurance for silver and gold.

6. Other aspects

There are several other aspects that will also contribute to an enabling environment, including:

- **Capacity building/training:** Just as in any other sector, new techniques and practices are invented in agriculture. To be able to benefit from all these innovations, it is necessary to constantly learn and update your knowledge. Also on climate change and how best to be prepared for this, is something you can learn, for example via extension services or training programs. However, extension services and training by COCOBOD or other stakeholders are not available in all communities. As a farmer, or farmers' group, you need to check which organization(s) provide extension services and training, and try to link up with them. In case none is available, you can discuss with your community how this can be organized.
- **Working in groups:** Most strategies are difficult to implement by yourself or will have less impact when done by one person. Most climate adaptation strategies would be most effective when farmers build assets together and take communal or landscape approaches, rather than farm-to-farm efforts.
- **Access to finance:** Without access to finance, most climate-smart technologies may not see the light of day. Perhaps linked to farmer groups and need for farmers to build assets and develop a culture of savings to improve their credit worthiness.

Topic 8: Increasing Resilience

Climate-Smart Agricultural Practices

MINIMUM	BRONZE	SILVER	GOLD
All zones			
Awareness, knowledge and adoption of main CSA practices as capacity building	Competencies of individuals, collective capabilities of groups, and overall system capacity to achieve CSA goals	Soft capacities: learning, adaptation, relationships with members and transfer of knowledge to community members, etc. Hard capacities: products, services, results	
		Fire management plans as Natural Resource Management (NRM)	
Coping and risk zone			
	Ground cover or lower canopy species such as black pepper and others as diversification		Ground cover or lower canopy species such as black pepper and similar as diversification
		Alternative livelihoods enterprise such as bee keeping, grass cutter rearing, etc. as diversification	
			Landscape or watershed management plan as NRM
			Land title registration and development of cropping calendar as farm planning
			Climate risk insurance e.g. yield insurance

MINIMUM	BRONZE	SILVER	GOLD
Adjustment zone			
		Alternative livelihoods enterprise such as bee keeping, grass cutter rearing etc. as diversification	
	Cocoa (3x3m) plus black pepper and others as diversification	Ground cover or lower canopy species such as black pepper and similar	
	Cocoa (3x3m) -plantain (interspaced) -*Terminalia spp*. (20m)- Integrate Allanblackia and other multi-functioning tree crops as diversification		
	Cocoa (3x3m) plus *P. africana* (10x10m) as diversification		
	Provide shade in riparian zones using water tolerant native species to enhance ecosystem services (moderate soil and air temperatures, retain soil moisture, create a conducive microclimate) for cocoa as NRM.		Restore forest cover of degraded shelterbelt and head water forest reserves in the cocoa belt as NRM.
	Simple farm map (with/without GPS coordinate	GPS mapping of farm; Land title registration; Registration of trees on farm; Farm development plan	
	Development of cropping calendar		
		Climate risk insurance	

MINIMUM	BRONZE	SILVER	GOLD
Transformation zone			
Awareness, Knowledge and adoption of main CSA practices	Competencies of individuals, collective capabilities of groups, and overall system capacity to achieve CSA goals	Soft capacities: learning, adaptation, relationships with members and transfer of knowledge to community members, etc. Hard capacities: products, services, results	
	Alternative livelihoods enterprise such as bee keeping, grass cutter rearing etc. as diversification		
Cocoa (3x3m) plus cola spp (6 x6m, 8x8, 10x 10) plus plantain and cocoyam as diversification	Ground cover or lower canopy species such as black pepper and similar as diversification		
Cocoa (3 x3) -plantain (interspaced) -*Terminalia superba* (20m)- as diversification		Grafted cocoa (2x2m) - cashew (10m distance). Switch over from cocoa to cashew and/or other more climate and soil suitable crops as diversification.	
	Cocoa (3x3m) plus *P. africana* (10x10m) as diversification		
	Provide shade in riparian zones using water tolerant native species to enhance ecosystem services (moderate soil and air temperatures, retain soil moisture, create a conducive microclimate) for cocoa.	Mobilize community action to restore forest cover of degraded shelterbelt and head water forest reserves in the cocoa belt	
		Land title registration; Development of cropping calendar	
		Climate risk insurance	

Topic 8: Increasing Resilience

GUIDELINES FOR TRAINERS

Materials needed:

- ☑ An elastic band
- ☑ Flip-sheet, markers and masking tape to paste the flip-sheet on the wall
- ☑ A4 sheets to draw farm plans (1 for each participant)

Time needed:

2 hours

Preparations:

- ☑ Carefully read the fact sheet, additional information and guidelines.
- ☑ Draw a farm plan on a flip-sheet. You can find an example at the end of this topic.
- ☑ Draw a cropping calendar of cocoa on a flip-sheet. You can find an example at the end of this topic.
- ☑ Draw a riparian zone on a flip-sheet or copy the example at the end of this topic.
- ☑ Draw a shelterbelt on a flip-sheet or copy the example at the end of this topic.
- ☑ Prepare a flip-sheet with the following text:

Actions to increase resilience:

1. *Farm planning*
2. *Diversification*
3. *Natural Resource Management (NRM)*
4. *Quality control*
5. *Insurance*
6. *Other aspects*

Set up

Attention:	Show the drawing of the farm and say that a lot of factors that are out of our control influence what is happening on our farm. Although you cannot influence these factors, you can be prepared in case any of these factors occur.
Title:	Tell the title of the session: Increasing resilience.
Objectives:	To explain what resilience is and actions you can take to increase your resilience and be prepared for difficult situations.
Benefits:	Although it is difficult to influence external factors yourself, it is important to realize that they will affect you and your farm. In addition, all these factors will be influenced by climate change and can therefore create extra challenges. To ensure that you are ready to cope with these extra challenges, you will need to increase your level of resilience. When you know how to increase your resilience, you can be prepared for difficult situations and you are able to keep your production at the same level, even if something happens.
Direction:	During this session, we will focus on diversification, Natural Resource Management (NRM), farm planning, quality control, insurance, and other aspects.

Delivery

Explanation, Demonstration, Exercise, and Guidance:

1. Refer to the factors that are **out of our control** that **influence** our farming. Ask: *Can anyone mention any of these factors?* Collect several answers. These factors can be climate change, the height of cocoa prices and agro inputs, rules and regulations from the government, availability of planting materials or new technologies.

2. Although you cannot influence these factors, you can be **prepared** in case any of these factors change. In other words, you can increase your **resilience**. Ask if anyone can explain what resilience is. Let several people try. Resilience is the ability to bounce back from difficulties or the capacity to **recover quickly** from challenges. Show the elastic band and say that resilience is like an elastic band; it does not matter how you pull it, it will spring back into shape when you release it (demonstrate this). This means that as cocoa farmer you are **prepared for difficult situations** and you are able to keep your production at the same level, even if something happens.

3. Show the flip-sheet with the **actions** you can take to **increase your resilience**. Start with the first action: f**arm planning**. Say that irrespective the impact of climate change on your cocoa, you can prepare yourself much better if you **know the situation on your farm**. The first step is to develop a farm plan. **Show your farm plan**. Point to your trees, the river, houses, neighboring farm, etc.

4. Do the following exercise. Give everyone a sheet: everyone should try to **draw a plan of his/her farm**. Walk around to guide participants.

   Note for trainer: The purpose of this exercise is not to get a correct farm plan, so people should not worry too much about exact measures; it is more to give people a feeling about their farm and to use it for other exercises in this topic.

5. Ask 2-3 volunteers to show their map to the group. Ask:

   a. We all made estimates about the farm size. *How can we know the **exact measurements** of our farm?* By using **GPS coordinates**.

   b. *How can a farm plan help us to **create resilience** or to be better prepared for what is going to happen on our farm?* Let several people answer. Mapping of farms will give you an exact idea how large your farm is which can help you to better plan when you would like to replant trees, purchase fertilizer or pesticides to avoid any waste, or estimate your yields. It also helps to better understand the situation on your farm and you can better plan for example how to protect vulnerable areas on your farm and where to dig trenches or plant trees.

6. Say that another way to know what is going to happen on our farm, is to develop a **cropping calendar**. Say that a cropping calendar depicts the period in which activities are done. Ask: *What type of activities are done on our cocoa farm?* When someone mentions an activity, ask: *In which period do we do these activities?* After discussing several activities, paste your cropping calendar on the wall and point to the activities and periods that were mentioned.

7. Ask: *How can a cropping calendar help us to **increase our resilience**?* Collect several answers. If you know what activities need to be done during what period you can **better plan** towards this. For example, you can ensure that certain equipment or inputs are available when you need them.

8. Say that another aspect of farm planning are **land title documentation and registration**. Ask: *What do we mean with land titles and registration?* It means that in case you are the owner of the land, you register this so everyone knows that you are the **land owner**. In case you do not on the land, it might be an option to become the owner. Ask: *How can this help you to increase your resilience?* If you want to manage your farm well, you should be the person who can take decisions on how to manage it.

9. The last aspect of land planning we will discuss here is the **registration of trees on your farm**. Say that currently, Ghana is working on a system in which you can register the trees on your farm. Ask: *How can tree registration help us to create resilience?* Trees play an important role in strategies to adapt to climate change. To protect them and use them to mitigate negative impact of climate change, you need to be the person who can **decide** how to manage the trees on your farm.

10. Continue with **diversification**. Point to your farm plan. Say that at the moment you are only growing cocoa. Diversification means to include **other ways of income** in addition to your cocoa farm, so you no longer dependent on one crop, in this case cocoa, which will make you less vulnerable when something happens to that crop. One way to diversify your source of income, is by planting **other cash or food crops** with your cocoa.

11. Ask: *Can someone make a suggestion what other crops I can plant on my farm?* In case someone has a suggestion, ask the person to indicate (by pointing) on your farm plan where he/she would plant that crop (on the farm next to your farm? in between the trees?). Let several people give suggestions for crops.

12. Ask everyone to take their own farm plan (that was drawn under point 4) and let them discuss in pairs **what type of crops they could plant** on their farm.

    Note for trainer: Also in this exercise, the purpose is not to develop a business plan, but rather to start the thinking process of what could be possible on their farms in terms of diversification.

13. In case someone mentions **trees**, ask what type of trees we could plant. See the fact sheet for suggestions. Ensure to mention the additional values of the trees and refer to topic 5 on Tree management. When you finalize the discussion, say that in a changing climate, it will be **more difficult to grow cocoa** in certain zones in the near future. Especially in the **transformation zone** with higher temperatures, reduced rainfall, prolonged dry season, and drought, the negative impact will **seriously affect cocoa production negatively**. To avoid that this will happen, it is wise to look ahead to the future and explore additional sources of income.

14. Continue with **Natural Resource Management**. Natural resource management refers to the **management** of **natural resources** such as land, water, soil, plants and animals. Ask:

    a. *What type of actions from us or other people will **destroy natural resources**?* Cutting of trees, illegal mining, pollution of waterbodies, the conversion of forest to agriculture crops, etc.

    b. *Why is it important to conserve our natural resources, especially in a changing climate?* We need the **environment and biodiversity** to produce our cocoa. A changing climate does not only negatively impact your cocoa but also the environment and biodiversity.

15. Refer to your **farm plan**. There are a few things we can do to protect the environment and biodiversity. The first one is to prevent **bush fires**. Ask: *How can we prevent bush fires?* Collect several answers. We can avoid bush fires by **not burning anything** on or nearby our farm and ensuring that equipment (such as chainsaws and mist blowers) does not give **sparks**. Add that they can also prepare a **fire management plan**. For example, you can make sure you have **equipment** to fight fires at hand on your farm (buckets with sand), or you can create **fire belts**. A fire belt is an empty strip of land around your farm. In case there is a bush fire, the fire will die on that strip of land before it will reach your farm. Ask is someone can **draw** on your farm plan where to make a fire belt. Then ask everyone to look at their **own farm plan** to see where they would create a fire belt.

16. Continue by saying that cocoa farms in landscapes where the **riparian cover** is destroyed will show **less resilience** to climate change compared to landscapes where the ecosystem services of riparian areas are conserved. Refer to your farm plan. Ask: *What is a riparian area?* The riparian area is the area between land and a river or stream. **Show your drawing** of the riparian zone. Ask: *Can anyone indicate on my farm plan where the riparian zones are?* Let someone point to the riparian area and correct if necessary. Say that in the riparian area you can **provide shade** by planting **water tolerant native species**, such as *T. scleroxylon*. The trees will enhance ecosystem services such as moderate soil and air temperatures, retain soil moisture, create a conducive microclimate. Be aware that some species, including Eucalyptus, take up a lot of water, resulting in drying up of water bodies.

17. Another thing we can do to protect our natural resources is to **create or restore shelterbelts**. Ask: *What are shelterbelts?* **Shelterbelts** are a line of trees or shrubs planted to protect an area, especially a field of crops, from fierce weather. **Show the drawing of the shelterbelt**. Ask if someone can draw on your farm plan where to plant such a shelterbelt. Then ask everyone to look at their **own farm plan** to see where they would create or restore shelterbelts.

18. To protect wildlife for the purpose of biological control of cocoa pests, the first step is to **learn about endangered species** in your area and which of them are useful to control pests and diseases. Ask: *Who can mention any endangered animal or insect that is useful to control pests on our cocoa farm?* Collect some answers. Add that another step is to make your farm **wildlife friendly**, for example by not leaving garbage on your farm that are dangerous for wildlife when they eat it (such as plastics) and not placing any traps on and around the farm. It is also important to **provide food and shelter** for wildlife, for example by preserving waterbodies (by not polluting them), preserving insects and other animals that can serve as food, and preserving trees on and around your farm.

19. Finally say that not only you but also **your community** can be mobilized in preserving natural resources. You can discuss within your community how to protect your area from illegal mining, restore forest cover of degraded shelterbelt, and headwater forest reserves. Instead of separate actions as listed above, you can also prepare a **landscape or watershed management plan** in which you will list what the current situation is, the changes you expect, and the actions you can take to mitigate the impact.

20. Continue with the next point: **Quality control**. Say that with irregular weather patterns, such as less predictive rain, it will be **more difficult to dry your cocoa** in the proper way. If your beans are not properly dried, the risk of mold is higher and will reduce the quality of the beans, which can lead to less money for your beans in case they are refused by the buyer. You can avoid this by looking at alternative ways to dry your beans, for example solar dryers as we have seen topic 4 on crop management.

21. Continue with **insurance**. Ask: *Who of you has any type of insurance?* Let people raise their hands. Ask if someone would like to **share** what type of insurance he/she has. Ask: *Why do you have insurance?* To avoid that when something happens, you have the **funds** to deal with it, for example that you can have an operation when you get sick or repair your motorcycle when it is damaged in an accident, or that your family can still survive when you die.

22. You can also get **climate risk insurance**, e.g. yield insurance. Unfortunately, this option is not yet available in Ghana but significant progress is being made towards yield insurance.

23. Continue with the last point: **other aspects**. Mention the points that are listed in the fact sheet (capacity building/training, working in groups, and access to finance).

Finish

Summary:

Repeat what resilience is and the 6 actions we can do to increase our resilience. Give a summary using your farm plan to repeat aspects of farm planning, diversification and natural resource management. Mention the solar dryer and crop insurance.

Questions:

Ask if anyone has a question or comment.

Evaluation:

Ask the following questions:

- What is resilience?
- Why is it important to increase our resilience?
- What can we do to increase our resilience?

Next step:

When you go back to your farm, see what you can do to increase your resilience so you will be able to keep your production at the same level, in case something happens.